Technical Manual

QuanX

Energy Dispersive
X-ray Fluorescence Analyzer

Thermo NORAN

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Thermo NORAN Inc.

2551 W, Beltline Hwy.
Middleton, WI 53562

Customer Support (800) 495 3839 or (650) 562 2500 (Outside US and Canada)
Email: support@thermonoran.com
Web: www.thermonoran.com

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1. General Information

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1.1 Introduction

This service manual describes the Spectrace Instruments QuanX analyzer.

The manual is designed to acquaint the service technician with the instrument, its hardware and software characteristics, its installation, and the service procedures that can be performed on-site.

This manual is written for service technicians who have general experience with electronic circuits and standard bench instruments. No expertise with X-ray or elemental analysis techniques is assumed (the references listed in this section should enable the interested reader to get acquainted with these topics).

This manual does assume that anyone working with the QuanX has become somewhat familiar with its operation as described in the Operator's manual.

The following conventions are used in this manual:

QuanX refers to the hardware or complete system.

QUANX (all caps) refers to the DOS software used to run the system.

ECD means Electrically Cooled Detector, and sometimes refers to QuanX systems equipped with the ECD.

LN means Liquid Nitrogen but in this manual also refers to the LN cooled detector and QuanX systems equipped with the LN detector.

See the Introduction to the Safety Chapter for additional conventions regarding Warnings, Cautions, and Notes.

1.2 Scope of the Manual

To achieve its stated goals, the manual is organized as follows:

Section 1. General Information

This section describes Spectrace Instruments service practices, the organization of this manual, additional Spectrace or OEM documentation, and other information of general interest.

Section 2. Safety

This section is a compilation and explanation of safety notices and precautions applicable to the instrument.

Section 3. Product Description

This section provides an overview of the instrument, and a summary of its specifications.

Section 4. Theory of Operation

This section provides a functional description of the instrument.

Section 5. Installation

This section contains instructions for the mechanical assembly, software installation, and testing necessary for proper installation of the instrument.

Section 6. Maintenance

This section contains a program for maintenance of the instrument including items requiring service, the applicable procedures, and tests for verifying proper operation.

Section 7. Test and Adjustment Procedures

This section contains detailed procedures for the adjustment, calibration, and testing of the instrument and its component modules.

Section 8. Diagnostic Software

This section describes the diagnostic software used as part of the various service procedures.

Section 9. Component Replacement

This section contains detailed instructions for component replacement.

Section 10. Troubleshooting

This section contains a list of error messages and a guide to troubleshooting, presented as a table of symptoms, causes, and remedies.

Section 11. Optional Equipment

This section gives an overview of some of the standard options available on the QuanX.

Section 12. Drawings and Schematic Diagrams

This section contains electrical and mechanical drawings.

1.3 Reference Documents

Spectrace Manuals and Publications

QuanX Operator's manual part number 0120-0040.

Energy-Dispersive X-ray Fluorescence Spectrometry: An Introduction, Spectrace Instruments 1994.

1.4 Service and Support

Telephone Support

A service technician is available for help or information, normally the technician responsible for your geographic region. To obtain the technician's direct number or if the technician is not available, call:

Spectrace Instruments
Customer Service
408-744-1414

Remote Diagnostic Troubleshooting

Spectrace is equipped to troubleshoot the QuanX via a modem hookup with the instrument. Extensive troubleshooting is provided if both parties feel the problem may be resolved over the telephone.

On-Site Service

On-site service is available after initial contact and troubleshooting via the phone.

Service Contracts

Spectrace offers a service contract that will provide the customer a means of maintaining the instrument with the highest on-line time possible. Various designs are available to suit the customers needs. Contact a customer service representative for more information.

Spare Parts

Several spare parts kits have been carefully selected as a means to provide very high on-line time. On-site spare parts have proven a valuable tool in conjunction with the remote diagnostic troubleshooting capabilities to reduce down time to a matter of hours. Various proposals have been designed to suit the needs and budget of the customer. Contact your sales representative for a list and price quote.

Customer Involvement

During the warranty period, the user may be requested to perform simple tasks to assist the technician in localizing the problem. This may include voltage measurements, board/module swaps, or running special software routines. Complex technical skill is not expected. After the warranty period, the degree of involvement is the user's choice.

Training

From time to time, Spectrace Instruments offers on-site and in-factory operational training for users (Spectrace User School). On-site hardware maintenance training is also available.

Equipment Exchange

All subassemblies are available for instant exchange. Spectrace Instruments normally responds within one working day of the initial request.

Return Authorization

Any time a part is to be shipped back to the factory, a RETURN AUTHORIZATION number must be issued and included with the part. Contact a customer service representative for the authorization number.

Repackaging for Shipment

Whenever possible, packing materials should be saved for use when components must be returned. Sensitive components such as the X-ray tube and the detector assembly require special care in packing. Call Spectrace Instruments customer service for instructions.

2. Safety

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2.1 Introduction

The QuanX system has been designed to meet all safety requirements applicable to industrial electrical and radiation devices. However, potential hazards exist in the operation and service of all electrical equipment. In addition, the QuanX and the OEM equipment built into it present potential hazards specific to their modes of operation.

Spectrace Instruments provides information about its products and the potential hazards associated with the use and care of these products. The instructions and information presented in this manual are intended to help the service technician develop safe habits for working on the QuanX. WARNINGS, CAUTIONS and NOTES are an integral part of the instructions and in accordance with federal, UL and industry standards, are used as follows:

WARNINGS indicate that failure to follow instructions or precautions can lead to injury or death.

CAUTIONS indicate that failure to follow instructions or precautions can lead to damage to equipment.

NOTES convey information that can help the user (operator or service technician) get optimum performance from the equipment. The use of NOTES implies no hazard to users or equipment.

Spectrace Instruments makes no representation that the readers of this manual are qualified, or that the act of reading this manual renders them qualified, to install, troubleshoot, maintain or repair the QuanX system.

Service technicians must be thoroughly familiar with and understand the safety procedures, know how to recognize hazardous or potentially hazardous conditions, and know how to take adequate precautions to protect themselves and others from possible injury.

Address questions and comments regarding safety to:

Spectrace Instruments
1275 Hammerwood Avenue
Sunnyvale, CA 94089
(408) 744-1414
Attn: Customer Service

2.1.1 Responsibility for Safe Operation

X-ray producing equipment should be used only under the guidance and supervision of a responsible qualified person. All equipment operators must be given adequate radiation safety instruction as specified by governing state regulations.

Adequate precautions should be taken to make it impossible for unauthorized or unqualified persons to operate this equipment or to expose themselves or others to its radiation or electrical dangers.

Before utilizing the equipment it is suggested that all persons designated or authorized to operate it, or supervise its operation, should have a full understanding of its nature and should also become familiar with established safe exposure factors by a careful study of the appropriate documents listed below:

- Security X-ray Cabinet Systems: Bureau of Radiological Health Performance standard for Cabinet X-ray Systems (21 CFR 1020.40)

  Order from: Bureau of Radiological Health
  FDA Fishers Lane
  Rockville, MD 20852

- Industrial X-ray Equipment: National Bureau of Standards Handbook 114 (ANS N543-1974)SD Catalog No. C13.11:114

- Industrial X-ray Equipment and Analytical X-ray Equipment: National Bureau of Standards Handbook 111 (ANS N43.2-1971)SD Catalog No. 13.11:111

  Order from: Superintendent of Document
  U.S. Government Printing Office
  Washington, D.C. 20402

2.1.2 Responsibility for Maintenance

The maximum operating voltages and currents, or ranges of voltages or currents, are set at and established by the factory and should not be altered except as explained in this Company's instructions. By exceeding established limitations, the effectiveness of the incorporated shielding may be reduced to a point where the penetrating or emergent radiation may exceed safe values. If radiation shielding shows chemical or mechanical damage, service personnel should be notified immediately to prevent accidental radiation exposure.

All parts of the equipment, particularly interlock switches, should be carefully maintained for proper operation. Doors and covers should close sufficiently to prevent access before interlock switches close.

Interlock switches are built into the sample chamber baseplate and the instrument frame. These switches should under no circumstances be tampered with and should be maintained in proper operating condition. In no case should they be defeated or wired out, since failure of automatic high voltage and X-ray exposure protection will then result.

Before changing X-ray tubes or making any internal adjustments to the X-ray high voltage, the equipment must be disconnected from the power supply to insure that no X-ray emission can occur. Care should be taken to assure that all high voltage condenser charges are removed using an insulated grounding lead, before personal contact is established.

2.1.3 Survey Meters and Dosimeter Badges

Regular radiation survey of the instrument may be desired, or in some cases required by your state. A survey meter designed to be used with X-radiation in the energy range of at least 30 to 50keV is required. One such model is the Victoreen 493 with a 489-35 GM probe. The response of this type of meter is kV dependent, therefore the true reading is obtained by applying a correction factor to the apparent reading (as explained in the meter manual). It is available from:

Victoreen, Inc.
6000 Cochran Road
Clevland, Ohio 44139-3395
(216) 248-9300

Spectrace Instruments recommends the use of personal dosimeter badges for all personal operating radiation producing devices. This may be required by your state as well. Normally a contract is established with a qualified vendor for monthly exchange and examination of badges. One such company is:

Radiation Detection Company
162 Wolfe Road
Sunnyvale, CA 94088
(408) 735-8700

2.1.4 State Mandated Safety Requirements

Most states in the USA require registration of any radiation producing device and several states require regular safety testing and on-site inspections. Contact your state department of health to determine your local requirements.

A typical requirement may include at least the following procedures:

- Semiannual safety interlock functional test following a written procedure.
- Semiannual radiation survey using an appropriate survey meter.
- Annual or semiannual certified calibration of the survey meter.
- Maintenance of a log book indicating the tests performed, the date, and the results.
- Formal employee training in basic radiation safety. Record of the training provided should be maintained for state review. Training may be required regularly or only once for each employee.
- Use of personal and/or area dosimeter badges.

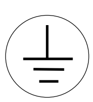
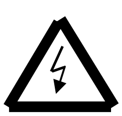
Some states will also perform random on-site inspections which include review of your log book and your local safety practices and written procedures.

The radiation survey and interlock test procedures may be found in Section 7 of this manual, Test and Adjustment Procedures.

2.1.5 IEC 1010-1 Safety Requirements

The QuanX system has been designed and verified by independent testing to meet the applicable requirements of IEC Standard 1010-1, “Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use”.

The following symbols are used to mark the QuanX according to IEC 1010-1:

Symbol	Description	Publication
	Fuse	IEC 417, No. 5016
	Protective conductor terminal	IEC 417, No. 5019
	Caution, risk of electric shock	ISO 3864, No. B.3.6

	Caution (refer to accompanying documents)	ISO 3864, No. B.3.1

Per IEC 1010-1, the power cord acts as a mains disconnection device on the QuanX. Therefore, ensure that the power cord is easily accessible at all times.

2.2 Radiation Hazard -- X-rays

WARNING
X-rays are injurious to health. Never energize the X-ray tube if the safety features of the instrument have been damaged or defeated.

Nature of the hazard

Although this equipment is safe to use and is designed to prevent accidental exposure, any X-ray producing equipment can be dangerous to both the operator and persons in the immediate vicinity unless safety precautions are strictly observed.

Exposure to X-rays is injurious to health. Therefore users should avoid exposure, not only to the direct beam but also to secondary or scatted radiation which occurs when an X-ray beam strikes or has passed through any material.

Preventive measures

It is especially important that users and technicians not try to circumvent or defeat the safety features built into the instrument. They should always be aware that the X-ray beam can constitute a distinct hazard if not employed in strict accordance with instructions.

Human beings have no senses for X-ray. Therefore, X-ray measuring instruments such as low energy X-ray Geiger counters must be used to detect X-ray emission or radiation leakage.

When test or troubleshooting procedures call for interlocks to be defeated temporarily, always disconnect the X-ray tube from the high voltage power supply.

The safety features of the QuanX include the following:

> The X-ray source, the sample and the detector are installed in an enclosure which provides adequate radiation shielding.
>
> The sample chamber, access doors and X-ray generation and detection components are protected by an interlock circuit.

A program (called XRAYOFF) is located in the AUTOEXEC.BAT file so it is executed automatically every time the PC is booted to make sure that the X-rays are turned off. This is useful in the event the computer failed—due to a power failure or some other cause—when the X-rays were still on. Note that there is no inherent harm in leaving the X-rays on as long as the interlocks are in proper working order. Thus the user or technician can turn the X-rays off by rebooting the computer (power off/on or press CNTL-ALT-DELETE).

2.3 Electrical Shock Hazard -- High Voltage

WARNING
Voltages and currents used in electrical equipment are capable of causing severe injury or death from electrocution. Avoid accidental contact with live circuit components.

Nature of the hazard

In electrical equipment the shock hazard is associated primarily with components of the AC distribution system such as circuit components, connectors, wiring termination points, and other exposed "hot" spots. In the QuanX, potentially lethal voltages and currents exist at the following locations:

- Inside the AC distribution box
- DC power supplies
- X-ray (high voltage) power supply

In addition, the high voltages used to drive the detector bias and the ECD ion pump have severe shock potential.

Preventive measures

Disconnect the AC power cord before working on electrical circuits.

WARNING
The ion pump power supply system contains a battery backup and will continue to generate high voltage with the AC power cord disconnected.

Emergency measures

When working on a live circuit, have someone stand by clear of the equipment ready to provide assistance. If an accident has occurs, this person should:

1. Immediately and carefully disconnect the power so as to cut off the electric current passing through the victim.
1. Not touch the victim until AFTER the power is off.

2.4 Poisoning Hazard -- Beryllium Window

WARNING

Nature of the hazard

The exit window of the X-ray tube and the entrance window of the X-ray detector are made of thin (<10 mil) beryllium foil. Beryllium metal is highly toxic. Do not touch or otherwise handle the foil.

Preventive measures

The beryllium windows on the X-ray tube and detector are extremely fragile and brittle. When installing, replacing, or working around the X-ray tube and the detector assemblies, proceed with great caution.

DO NOT touch, jar, or subject the beryllium windows to mechanical or thermal shock. DO NOT expose the beryllium windows to corrosive substances such as acid, acid vapor (such as from caustic samples), water, water vapor, or others substances. Protect the surface of the beryllium window by installing a collimator with a protective mylar window attached. Exercise caution when handling materials and samples in the vicinity of the beryllium window. Any physical contact with the window will almost certainly rupture it, even small particles can puncture the beryllium window.

Emergency measures

If breakage of a beryllium window occurs, proceed as follows:

1. Avoid touching, breathing or swallowing the particles and do not allow the particles to come into contact with your skin or clothing.
1. Gather all broken pieces and particles immediately using a pair of tweezers or the sticky side of masking tape.
1. Handle the beryllium pieces as you would a poison. Place them in a sealed, unbreakable container labeled “CAUTION: BERYLLIUM - POISON,” and contact the proper authorities for transport and disposal guidelines.

If the beryllium particles have come into contact with skin, remove them as described above and wash the affected area thoroughly.

If the beryllium particles have come into contact with clothes, remove and discard the particles carefully as described above. Wash the clothing thoroughly. Check for beryllium particles on the skin as described above.

2.5 Cryogen Burn Hazard – Liquid Nitrogen

WARNING
Cryogenic liquids and gases can cause severe burns on contact with skin, eyes or lungs. Do not allow skin contact with the liquid, and do not breathe the vapors boiling off the liquid.

Nature of the hazard

Liquid nitrogen exists at extremely low temperatures (-320°F, -196°C, 77K).

Skin contact with liquid cryogens or with boiled-off gases that are still at cryogenic temperatures can cause burns as severe as high temperature burns.

Breathing the vapor boiling out of the dewar can cause injury to air passages and lungs that is just as severe as burns from breathing hot gases.

Delicate tissues, especially the eyes, can be damaged even by a brief exposure.

Preventive measures

Always handle dewars very carefully. Always wear protective gear (gloves, clothing, goggles) when handling cryogens. Never breathe the gases boiling out of a dewar.

Stay clear of boiling and splashing LN. LN will always boil when it is transferred to a warm container or when something is inserted into it. Transfer LN slowly.

Never touch uninsulated plumbing or containers that hold LN. Skin may adhere to these cold surfaces and tear when pulled away. Never put hands in the LN.

Use only vessels designed for use with LN (e.g., LN dewars) for filling, transferring and using LN.

When filling dewars, use a metal funnel or one that is rated for low temperature.

Emergency measures

Treat LN burns as you would a case of frostbite. Contact a physician for medical attention.

2.6 Asphyxiation Hazard – Cryogen Boil-Off

WARNING

Prolonged boil-off of cryogens displaces air and the oxygen in it. This can lead to asphyxiation without warning. Store or use cryogens only in well-ventilated rooms.

Nature of the hazard

Liquefied cryogen is always boiling off a cold, dense gas from the dewar in which it is kept. The gas is colorless, odorless and non-toxic. However, it displaces the air and the oxygen in it that people need to breathe.

Preventive measures

Make absolutely sure that in any room where cryogens are used or stored the ventilation is adequate at all times.

Emergency measures

If a person should be overcome by lack of oxygen, ventilate the area or move the person to an area with normal oxygen levels and administer appropriate first aid and call for help.

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3. Product Description

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3.1 Introduction

The Spectrace QuanX is a compact high performance Energy Dispersive X-ray Fluorescence (EDXRF) analyzer. The instrument uses an X-ray tube excitation source and a solid state detector to provide simultaneous spectroscopic analysis of elements ranging from sodium to uranium in atomic number and in concentrations ranging from a few parts per million to 100 percent. Instrument control and data analysis are performed by a personal computer that is connected to the system.

For the purpose of introducing the reader to the QuanX, this section begins with a tour of the instrument. The name, function, and location of major components are described. This information provides a basis for understanding the other sections of this manual. The section concludes with detailed specifications of the unit.

3.2 A Tour Of The QuanX

3.2.1 Overall System

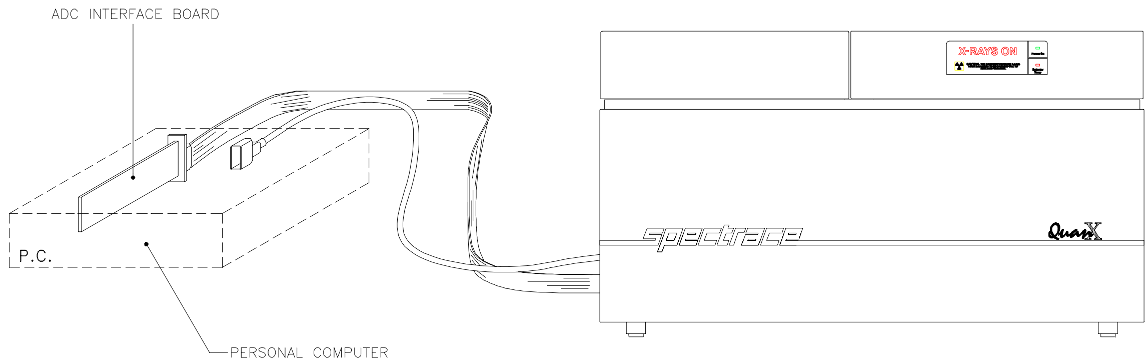

Figure 3-1 PC Interface

The system is composed of two parts: the instrument and the Personal Computer. The instrument contains the X-ray generating elements, sample chamber, detector, detector electronics, microprocessor controller and associated power supplies. The personal computer (PC) includes the ADC Interface board and other standard PC elements.

Figure 3-1 shows the connections between the QuanX spectrometer and the PC. Spectral data are transmitted to the PC via the ADC Interface cable. Instrument control is accomplished via the RS-232 serial connection. The PC sends commands (X-rays on, vacuum pump on, etc.) to, and receives status from, the chamber control board located in the QuanX card cage.

3.2.2 Component Identification and Description

Figure 3-2 shows a front view of the QuanX without a detector installed, and with the enclosure cover removed. Each item identified with a callout is discussed below.

The left lid on the top of the instrument can be opened to provide access to the detector and detector electronics. The configuration of components is different for the LN and the ECD models. In the LN model, the dewar is under the access cover. The dewar can be filled by removing the cap and adding LN until the level reaches the neck of the dewar. The LN cooled detector should be refilled each week regardless of whether the unit will be used or not. In the ECD model, the front area under the cover holds the ECD support electronics. Indicators and controls for the ECD Peltier coolers are located in this area.

The two interlock switches prevent the generation of X-rays and high voltage when the left lid is open or when the enclosure cover is removed. Both switches are of the “pull-to-cheat” design; the switch may be bypassed by pulling out on its actuator lever. Closing or installing the cover resets the actuator thereby restoring normal switch operation. This feature is useful for service purposes.

The lid latch assembly contains a solenoid and two switches. The solenoid is energized to lock the chamber lid closed whenever the X-rays are on. One switch detects if the solenoid plunger has traveled far enough to lock the lid, the other switch senses if the chamber lid is closed. Both switches must be activated before X-rays can be generated.

The sample chamber lid is lead lined for radiation safety and is vacuum tight for analysis of low atomic number elements.

The "X-RAYS ON" warning light is located in the sample chamber lid. This light indicates the status of the X-ray generator. Next to the warning light are the "Power On" and "Detector Temp" lights. The Power On light is on whenever the AC power switch located on the back of the unit is turned on. The Detector Temp light is normally off, but will flash if the detector is not at the correct operating temperature. For an LN detector, this indicates that LN should be added. For an ECD, this means the detector coolers are not maintaining the proper temperature. All the lights are mounted on a PC board called the display board.

The chamber lid interlock switch is the primary safety interlock device used to prevent X-ray generation when the chamber lid is open. A second lid interlock switch is part of the lid latch assembly previously described. The primary switch uses a *Positive-Break* (⊕) design; the contacts are forced open by a mechanical drive mechanism rather than by a spring as in a normal switch. It also features a bypass-resistant actuator which requires a unique-geometry actuator key to close the contacts.

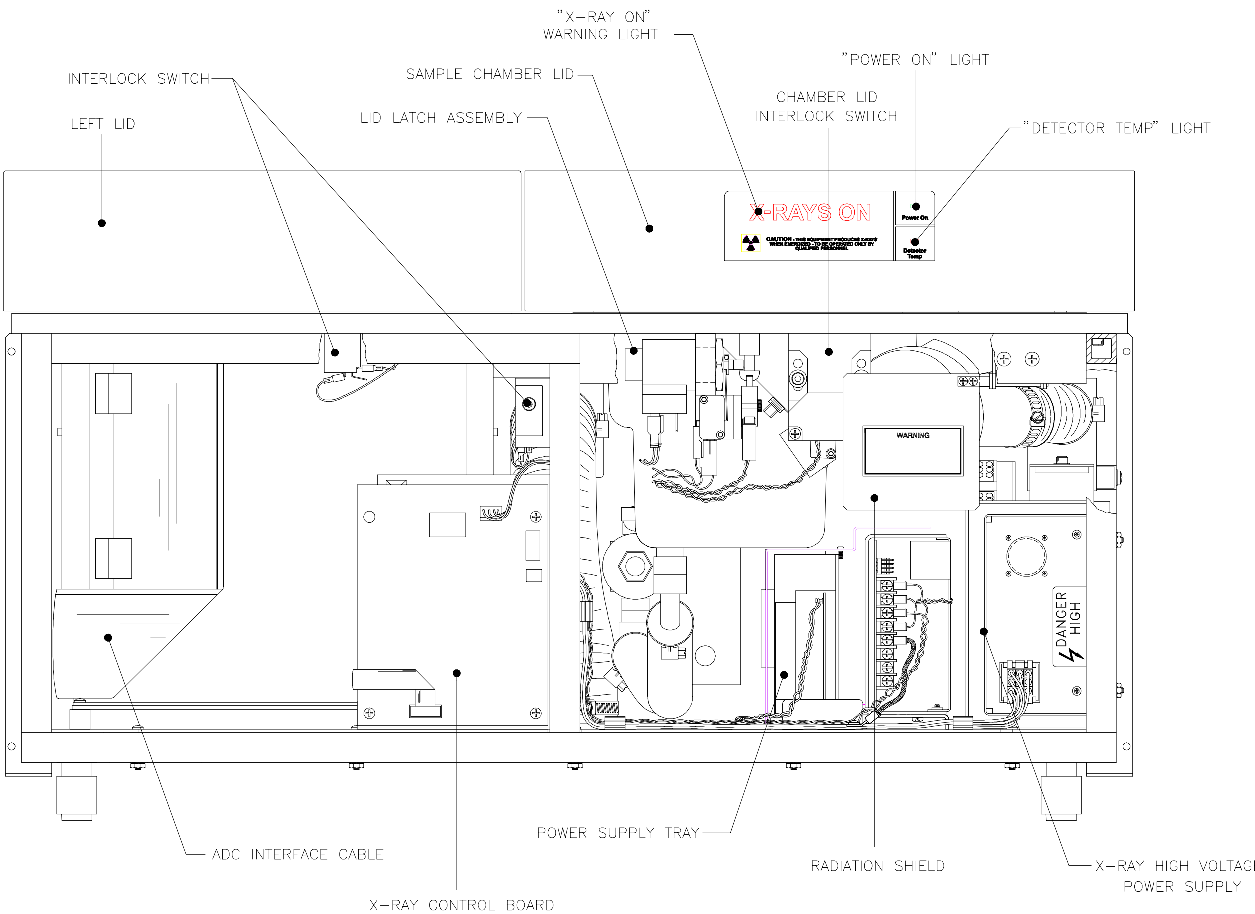

Figure 3-2 Front view

The X-ray high voltage power supply produces the high voltage required for X-ray tube operation. It operates on +24V DC and generates up to 50kV and up to 2mA with a 50 watt power limitation. The power supply is mounted in a shielded box to prevent noise pickup by the detector.

The radiation shield is a hinged steel plate used as a stop for stray radiation emitted from the X-ray tube housing. It is designed such that it must be in the normal, or "down," position before the enclosure cover will fit on the instrument. The shield may be flipped up for service access.

WARNING

To prevent exposure to radiation, the radiation shield must be in the normal, "down," position whenever X-rays are being generated!

The power supply tray holds all the DC power supplies used to power the instrument. These include two linear supplies which power the detector preamp and detector electronics, and two switching supplies which provide power for the X-rays and various machine functions. The tray slides out for service access.

The X-ray control board controls the voltage and current applied to the X-ray tube. It accepts digital commands from the chamber control board and executes them by setting the X-ray high voltage power supply to the desired voltage output, and adjusting power to (and thus the temperature) the X-ray tube filament to obtain the desired tube current. This board also is a junction point for many of the safety interlock circuit connections.

The ADC interface cable connects the ADC board located in the QuanX card cage to the ADC interface board located in the PC. This cable carries digital spectral data as well as ADC control and status information. The cable is a 50 conductor, fully shielded ribbon cable with high density shielded connectors at each end.

Figure 3-3 shows a right side view of the QuanX with the enclosure cover partially cut away. Each item identified with a callout is discussed below.

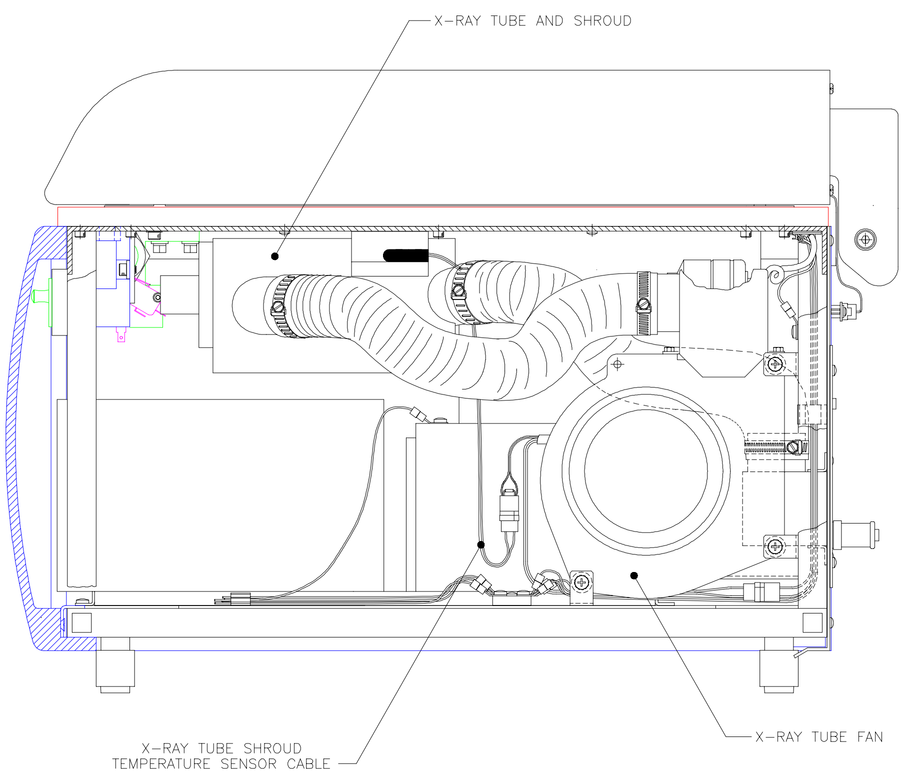

Figure 3-3 Right side view

The X-ray tube and shroud provide the primary X-ray beam used to illuminate the sample. The X-ray tube is air cooled and may operate at up to 50 watts. The target material of the X-ray tube determines certain characteristics of the tube's spectral output and is therefore selected based on the intended application of the instrument. For most applications a Rhodium (Rh) target X-ray tube is used. The shroud is part of the tube cooling system discussed below.

The X-ray tube fan is dedicated to tube cooling. The fan and shroud form a closed-loop, independent temperature control system. The fan speed varies based on the temperature of an external sensor which is bonded to the shroud surrounding the X-ray tube. The shroud is mechanically coupled to the tube with a heat conductive interface. Therefore as the tube heats up during use, the fan speed increases to provide additional cooling. This system serves to lower the fan speed when cooling demand is low, thereby reducing noise. It also serves to maintain a more constant tube temperature which is desirable for analysis stability. The warmed exhaust air is vented outside the cabinet to avoid increasing the internal ambient temperature. The fan is mounted on rubber isolators to prevent vibration of the detector.

Figure 3-4 shows a top view of a LN QuanX with the left lid and chamber lid removed. The metal cover plate inside the sample chamber is also removed to expose various components. Each item identified with a callout is discussed below.

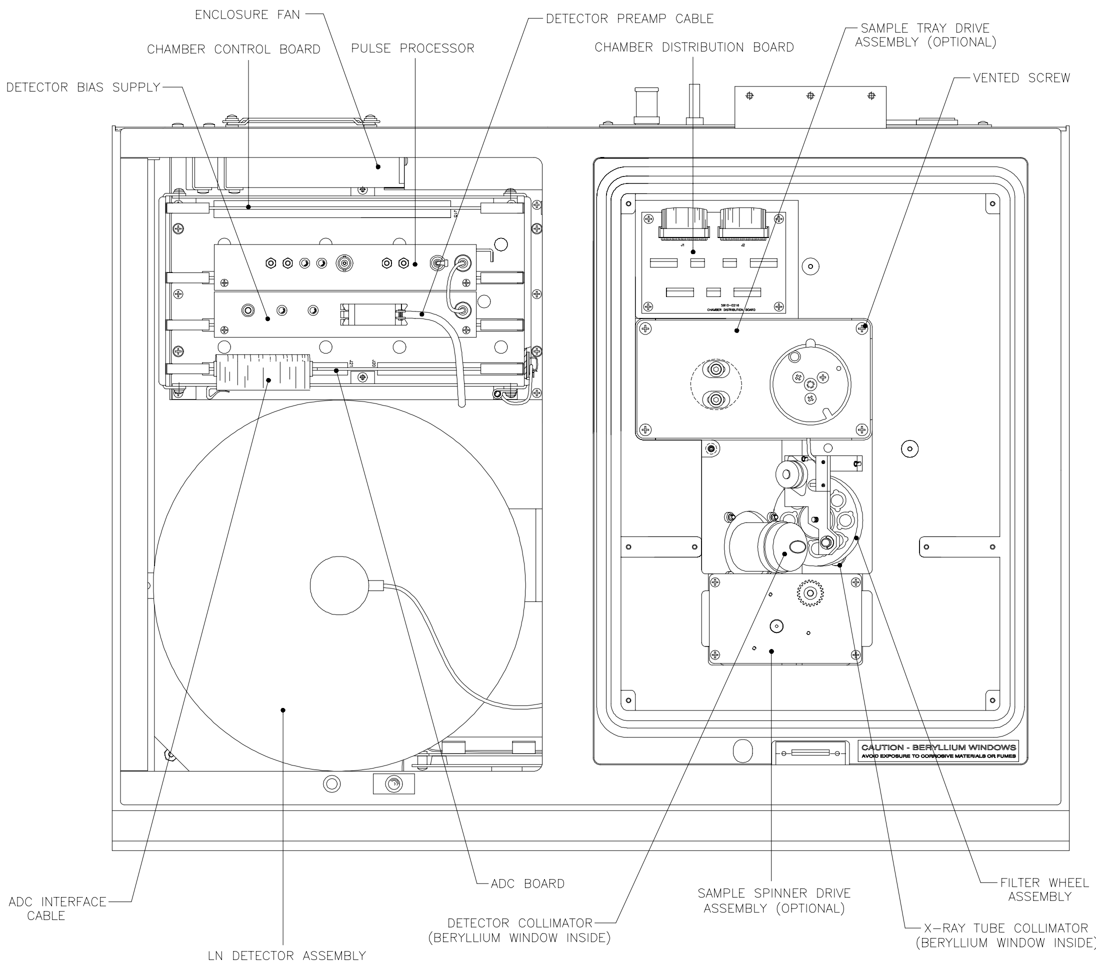

Figure 3-4 Top view, LN model

The detector bias supply provides the high voltage (300 - 600 VDC) required to operate the Si(Li) detector crystal. It is also the connection point for the other detector preamplifier signals and power supplies.

The chamber control board is a self-contained microprocessor based controller. It accepts commands from, and sends status to, the PC via the RS-232 serial communications link. It controls all machine functions such as rotating the sample tray and filter wheel, turning on and off the X-rays, monitoring the safety interlock circuit, turning on and off the vacuum pump, etc.

The enclosure fan provides cooling air for the entire enclosure. The fan speed is variable and is controlled by an external sensor mounted on the front of the card cage. When the cooling demand is low, such as when the room ambient temperature is low, the fan runs slower to reduce noise. The fan's output is ducted to an air plenum under the floor of the instrument. Cooling air is directed upward through a series of holes in the floor. In this way, directed spot cooling of critical components and overall enclosure cooling are performed simultaneously. The fan is mounted on rubber isolators to prevent vibration of the detector.

The pulse processor receives the detector preamplifier output signal. It provides pulse shaping and other signal conditioning to prepare the signal for conversion in the ADC. The controls for GAIN and

ZERO used for initial energy calibration as well as the FAST DISCRIMINATOR threshold adjustment are located here.

The detector preamp cable connects the detector assembly to the bias supply board. This cable carries the detector high voltage bias, the detector output signal, and several DC voltages.

The chamber distribution board is a connection point for the motors and sensors located inside the sample chamber. One or two (depending on options installed) cables connect this board to the card cage motherboard via vacuum tight feedthru fittings in the chamber wall.

The sample tray drive assembly (optional) drives the sample tray rotation. It consists of a step motor, drive belt, and optical position sensor. The motor is controlled by the chamber control board located in the card cage. The assembly may be easily removed or installed as a single unit.

The vented screws are used in several locations inside the sample chamber. These screws have a hole drilled along the axis of the screw. The hole allows trapped air to escape quickly from the bottom of the screw hole when the vacuum pump is turned on. This eliminates the "virtual leak" caused by trapped air and significantly reduces the chamber pump down time.

The filter wheel assembly is an eight position turret driven by a step motor. An optical sensor is used to detect the rotational position. Each position on the wheel may hold one transmission filter. The filters are used to modify the characteristics of the primary X-ray beam emitted from the X-ray tube and are selected based on the elements being analyzed. The motor is controlled by the chamber control board located in the card cage. This assembly may be easily removed or installed as a single unit.

The X-ray tube collimator serves to limit the X-ray beam size. The X-ray tube beryllium window is located just inside the collimator opening.

CAUTION

The beryllium window is extremely fragile and can be broken by the lightest touch. Never put anything down the collimator shaft or touch this window in any way. If the window becomes contaminated, contact Spectrace Customer Service for instructions.

The sample spinner drive assembly (optional), used together with the special 10 position sample tray, rotates the sample during spectral analysis. Rotation is used on rough or odd-shaped samples because the analysis results change depending on how the sample is placed in the tray. By rotating during analysis, the variances are averaged out. The drive assembly uses a step motor which is controlled by the chamber control board located in the card cage. The assembly may be easily removed or installed as a single unit.

The detector collimator limits the detector's field of view, reducing the incidence of unwanted X-rays. The detector beryllium window is located just inside the collimator opening.

CAUTION

The beryllium window is extremely fragile and can be broken by the lightest touch. Never put anything down the collimator shaft or touch this window in any way. If the window becomes contaminated, contact Spectrace Customer Service for instructions.

The LN detector assembly includes the liquid nitrogen dewar, the Si(Li) detector crystal, the preamplifier, and the beryllium window. It converts the X-rays emitted and scattered by the sample into electrical pulses. These pulses are amplified by the preamp before transmission to the pulse processor board. The LN dewar is a double-wall vessel with super-insulation and high vacuum in the space between the walls. The Si(Li) crystal is mounted to a cold finger extending from the dewar. The cold finger and crystal are also under the same high vacuum. The beryllium window acts as an X-ray transparent, vacuum tight seal. Instruments equipped with an ECD do not contain this assembly and are discussed below.

The ADC interface cable connects the ADC board located in the card cage to the ADC interface board located in the PC. This cable carries spectral data from the QuanX to the PC. The PC also sends commands to, and receives status from, the ADC board over this cable.

The ADC (analog-to-digital converter) board converts the pulse processor output signal from analog to digital data, in other words from a DC voltage proportional to X-ray energy to a channel number proportional to energy. It transmits the result to the ADC interface board in the PC.

Figure 3-5 shows a top view of an ECD QuanX with the left lid and ECD support tray's protective cover removed. Each item identified with a callout is part of the ECD support tray (except the ECD itself) and is discussed below.

The ECD control board performs various ECD support functions including temperature regulation and monitoring. Protection circuits include alarms for high ion pump current, high heat sink temperature, and high cooler drive voltage. Four LEDs on the board indicate the status of these alarms; each light is on under normal, non-alarm conditions. The cooler on/off switch is located on this board and is shown in the inset.

The ECD fan provides cooling air for the ECD heat sink.

The ECD (electrically cooled detector) assembly includes the Si(Li) detector crystal, the Peltier coolers, the preamplifier, and the beryllium window. It converts the X-rays emitted and scattered by the sample into electrical pulses. These pulses are amplified by the preamp before transmission to the pulse processor board. The Si(Li) crystal and Peltier coolers are under high vacuum inside the housing. The beryllium window acts as an X-ray transparent, vacuum tight seal.

The cooler power supply is a linear DC power supply with two outputs, one for the ECD external coolers and the other for the ECD internal coolers. This power supply is on whenever the instrument power cord is connected to an AC power source, even when the instrument power switch is in the off position.

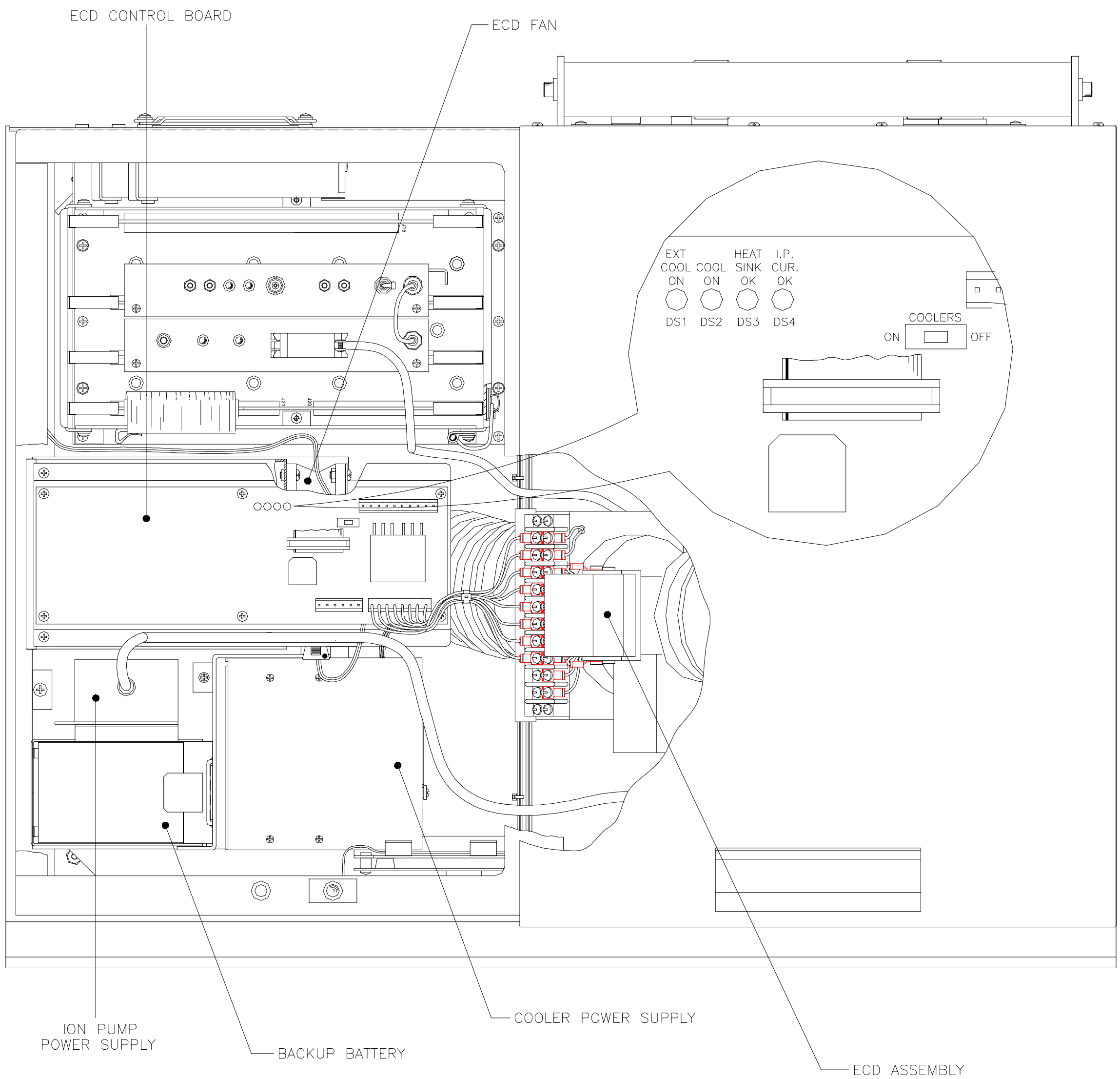

Figure 3-5 Top view, ECD model

The backup battery is a 12V, 7Ah sealed lead-acid battery. It provides power to the ECD ion pump power supply whenever the instrument power cord is not connected to an AC power source. The battery can support the ECD for up to 72 hours. It is automatically recharged when the instrument power cord is plugged in.

The ion pump power supply is a high voltage (3kV), low current power supply used to operate the ECD ion pump. The power supply operates on 12V DC which is supplied by the instrument power supplies when the instrument power cord is connected to an AC power source, or by the backup battery when the power cord is unplugged.

Figure 3-6 shows a rear view of the QuanX. Each item identified with a callout is discussed below.

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Figure 3-6 Rear view

The power on/off switch controls the power to part, or all of the instrument depending on the model. For instruments equipped with a LN detector, the switch controls all power to the instrument. For ECD equipped systems, the power switch only controls the power to the card cage. To prevent accidental warmup of the detector, the power supplies that support the ECD coolers and ion pump remain on even when this switch is in the off position. For these instruments, the power cord must be disconnected to remove all power.

The instrument power input and fuse is the connection point for the primary power cord. The connection is made via a standard IEC 320 inlet. The inlet module has UL, CSA, and VDE safety agency approvals. It is rated for line voltages of 115 or 230 VAC if the system line voltage selection switches are set accordingly. It supports both North American (single ¼" x 1-¼" 3AG fuse) or European IEC type (single or dual 5 x 20 mm fuses) shocksafe fusing requirements. Beginning January 1997, all units are shipped with IEC type fuses. See the Specifications section for fuse values.

The vacuum pump power input and fuse is the connection point for the second instrument power cord. The vacuum pump power circuit is separate from the instrument power to reduce the required capacity of an uninterruptable power supply or power conditioner, if one is used. The connection is made via a standard IEC 320 inlet. The inlet module has UL, CSA, and VDE safety agency approvals and is rated for line voltages of 115 or 230 VAC. The shocksafe fuse drawer also accepts either North American or IEC type fuses. Beginning January 1997, all units are shipped with IEC type fuses. See the Specifications section for fuse values.

The "X-RAY ON" warning light cable powers the display board located in the sample chamber lid. This cable must be connected before the instrument will turn on the X-ray source.

The AC distribution box assembly houses most of the AC wiring in the instrument. It is a closed, grounded metal box. It is the connection point for all external and internal AC line voltage cables. It also houses a line filter and a solid-state relay for vacuum pump control.

The RS-232 port is a DB9M connector used to connect the chamber control board to the PC COM1 port.

The external battery connector is a 2 pin connector used to connect an external +12V source to power the ECD ion pump during shipping or other extended power outages. The external battery works in conjunction with the internal backup battery to extend the time the instrument may be disconnected from an AC power source. The external battery is not recharged when the instrument is plugged into an AC power source. The connector mates to a Molex 09-50-3021 or equivalent connector. This connector is not used if the instrument has a LN detector.

The motherboard access panel may be removed to gain access to the system cabling. The motherboard is the junction point for most of the system power and signal cables.

The vacuum port is the connection port for the vacuum pump hose. It is a 5/8 inch barb hose fitting. Vacuum is used to analyze low atomic number elements because their low energy X-rays would be absorbed by the air in the chamber. Liquid samples may not be placed under vacuum.

The helium port (optional) is the connection point for the helium gas used to flush the sample chamber when analyzing low atomic number liquid samples. The input pressure must be in the range of 15 to 65 psi. The fitting is a ¼ inch hose barb.

The vacuum pump power outlet is a standard NEMA 5-15R receptacle. The vacuum pump power cord is plugged into this outlet. The vacuum pump must be rated for the AC line voltage connected to the vacuum pump power inlet, the instrument does not convert this voltage. This outlet is a switched outlet under the control of the analysis software. It is fused as previously described.

The computer power convenience outlets may be used to operate the PC. They are standard NEMA 5-15R receptacles. The voltage present at these outlets is identical to the AC line voltage connected to the instrument power inlet; the instrument does not convert this voltage. The outlets are not switched or fused. The maximum power rating for all three combined is 800 watts.

WARNING

AC line voltage is always present at the convenience outlets when the instrument power cord is plugged in, even when the instrument power switch is off.

The AC line voltage selection switches configure the instrument for operation on 115 or 230 VAC. Both switches must be set to the appropriate setting **before** the power cord is plugged in.

CAUTION

Failure to select the correct AC line voltage switch setting may cause instrument damage.

3.3 Specifications

PERFORMANCE

Elements Determined:	Sodium through uranium.
Concentration Range:	Parts per million to percent.
Accuracy:	Dependent on standards quality and concentration. Expected is 0.5 to 5.0% relative.
Precision:	Dependent on concentration and analysis time. Expected is 0.5 to 5.0%.
Calibration:	Typically monthly.

SAMPLE PHYSICAL PROPERTIES

Type:	Solids, powders, filtrates, liquids and thin films.
Size:	Standard single sample tray holds 1 ¼ inch (32mm) diameter sample cups or large, irregular samples up to the chamber size. Optional trays available for multiple samples, sample spinning, 47mm diameter samples, fixed disk data storage media, and wafers.

EXCITATION

X-ray Optics:	80^{o} geometry between X-ray tube, sample and detector. Distance from sample to: LN detector - 33.0mm. ECD detector - 28.5mm. X-ray tube target - 80.3mm.
X-ray Tube:	Side window Bremsstrahlung, Rh target, 50 watt, 127 micrometer (5 mil) Be window, air cooled. Optional targets and window thickness available.
X-ray Generator:	Voltage range, 4 to 50 kV in 1kV increments. Current range, 0 - 1.98mA in 0.02mA increments. Maximum 50 watt output.
X-ray Stability:	0.25% RSD over any 8 hour period.
Filters:	Automated 8 position filter selection. Al, cellulose, 2 Cu and 3 Pd filters are provided.
Filter Collimators (optional):	1mm, 3.5mm, 6.8mm
Chamber Environment:	Automated control of air, vacuum (optional) or helium (optional).

X-RAY SENSOR, ECD MODEL

Detector:	Si (Li) 15mm^2 area, ≤175eV FWHM resolution for 5.9keV X-rays at 1,000 cps.
Window:	≤14.0 micron (0.55 mil) Beryllium (Be).
Cooling:	Thermoelectric (Peltier) and air.
Preamplifier:	Pulsed optical reset.
Battery:	Backup battery for vacuum pump is a sealed design, Yuasa NP 7-12 7.0Ah or equivalent.

X-RAY SENSOR, LN MODEL

Detector:	Si (Li) 30mm^2 area, ≤155eV FWHM resolution for 5.9keV X-rays at 1,000 cps.
Window:	≤8.9 micron (0.35 mil) Beryllium (Be).
Cooling:	Liquid nitrogen. 8 liter capacity dewar, 1 liter/day consumption.
Preamplifier:	Pulsed optical reset.

SIGNAL PROCESSING SYSTEM

Pulse Processor:	Shaping network - time variant. Stability - 0.01%/^{o}C. Integral linearity - 0.1%. Pileup rejecter - pulse pair resolution is 250 nanoseconds above 2.5 keV and 1 microsecond below 2.5 keV. Live time correction - +/- 1.0% from 0 to 20 kcps. Computer selected time constants. Resolution degradation with count rate, in a given count rate range, is negligible in time variant pulse processors.
Analog to Digital Converter:	4,096 addresses, 100 MHz clock, automated energy calibration and zero correction.
Data Memory (ADC interface board):	2,048 data channels, 16 million counts/channel. 8-bit ISA bus compatible, full length slot. The data memory is the interface to the computer. Requires a 16k contiguous memory block within the C0000H to EFFFFH range. I/O map addresses used are 330H to 333H, no IRQ interrupts used. Power consumption: +5V DC @ 1.2 A.

DATA PROCESSOR

Computer: (Typical specifications. The PC may be user supplied)	IBM PC/AT™ compatible. 80486DX-33 or better CPU. 8 MB RAM. Fixed disk drive. 1.44 MB 3.5 inch floppy disk drive. VGA monitor. 101 key keyboard. Operating system - MS-DOS 6.0 and Microsoft Windows version 3.1 or higher. Two RS-232C serial ports. 28,800 bps modem. Graphics printer, IBM Proprinter™ compatible.

SOFTWARE

Operation:	Soft-key/menu selection.
Spectral Display:	X-ray spectrum (linear or log), procedure title, sample identification, kV, mA, filter, KLM markers, peak labels, energy cursor, energy scale, gross or net intensity of region of interest, preset live time, elapsed time, % dead time, and overlap comparison of two spectra.
Output:	VGA display, graphics printer.
Automation:	X-ray tube high voltage and current, filter selection, analysis and output.
Spectrum Processing:	Automatic element identification, background removal by digital filter, empirical peak unfolding by least squares fitting, gross peak intensities and net peak intensities above background.
Analysis Techniques:	Peak ratios, linear fit, quadratic fit, intensity matrix correction and two concentration matrix corrections. Normalization to a check-standard and display plots of calibration curves are included. A fundamental parameters program provides analysis with or without standards. Standards may be pure elements or compound standards of a matrix similar to the unknown.
Operating System:	MS-DOS version 6.0 and Microsoft Windows version 3.1 or higher.

Diagnostics:	PC monitoring of critical system parameters and system voltages. Full remote control capability via modem.

ENCLOSURE

Type:	Molded RIM polyurethane structural foam.
Installation:	Indoor only, bench top.
Dimensions (not including PC):	Height - 16.2 in (41.1cm) top lids closed 33.1 in (84.1cm) top lids open. Width - 28.3 in (71.9cm). Depth - 23.3 in (59.2cm). 27.0 in (68.6cm) including clearance for cables and lid.
Weight (not including PC or vacuum pump):	175-200 lb. (80-91kg). Approximate weight. Actual weight varies based on installed options and LN level.
Sample Chamber:	12.0 in (30.5cm) wide. 16.2 in (41.1cm) deep. 2.6 in (6.6cm) high. Maximum sample height is 2.0 in (5.1cm) high.

SAFETY

Interlocks:	Implemented for both lids, the presence of the X-ray tube and detector, the enclosure cover, and the "X-RAY ON" warning sign operation. Fail-safe circuit design. Dual interlocks on sample chamber lid with separate circuits and mechanical actuators. Primary sample chamber interlock uses a positive-break (⊖) type switch.
Radiation Leakage:	Less than 0.25 mR/hr at 2 inch distance from any surface.
Sound Pressure Level:	Less than 60 dbA at 1 meter from any surface.

OPERATING ENVIRONMENT

Ambient Temperature:	LN model - 32 to 93°F (0 to 34°C). ECD model - 32 to 86°F (0 to 30°C).
Relative Humidity:	20 to 80% RH (non-condensing).

UTILITY REQUIREMENTS & FUSING

Power (not including PC or vacuum pump):	100-120/200-240 VAC, 5/2.5 A, 50/60 Hz, single phase. LN model - 350 watts maximum. ECD model - 500 watts maximum.
Power, optional vacuum pump:	115/230 VAC, 50/60 Hz, 700 watts.
Power, personal computer (PC) system:	300-500 watts typical.
Fuse, instrument power:	Type - 5x20mm, fast acting, high capacity, IEC. 115 VAC operation - 5A. 230 VAC operation - 2.5A.
Fuse, vacuum pump power:	Type - 5x20mm, time lag. 115 VAC operation - 7A, UL. 230 VAC operation - 4A, IEC.
Fuse, convenience outlets:	Not fused.

OPTIONAL EQUIPMENT

Helium Flush:	Input pressure range - 15 to 65 psig (103-448 kPa). Consumption (flow rate): 2 minute purge - 15 scfh (425 l/h) during acquisition - 5 scfh (142 l/h) Fitting - ¼ inch hose barb.

3.4 Outline Drawing

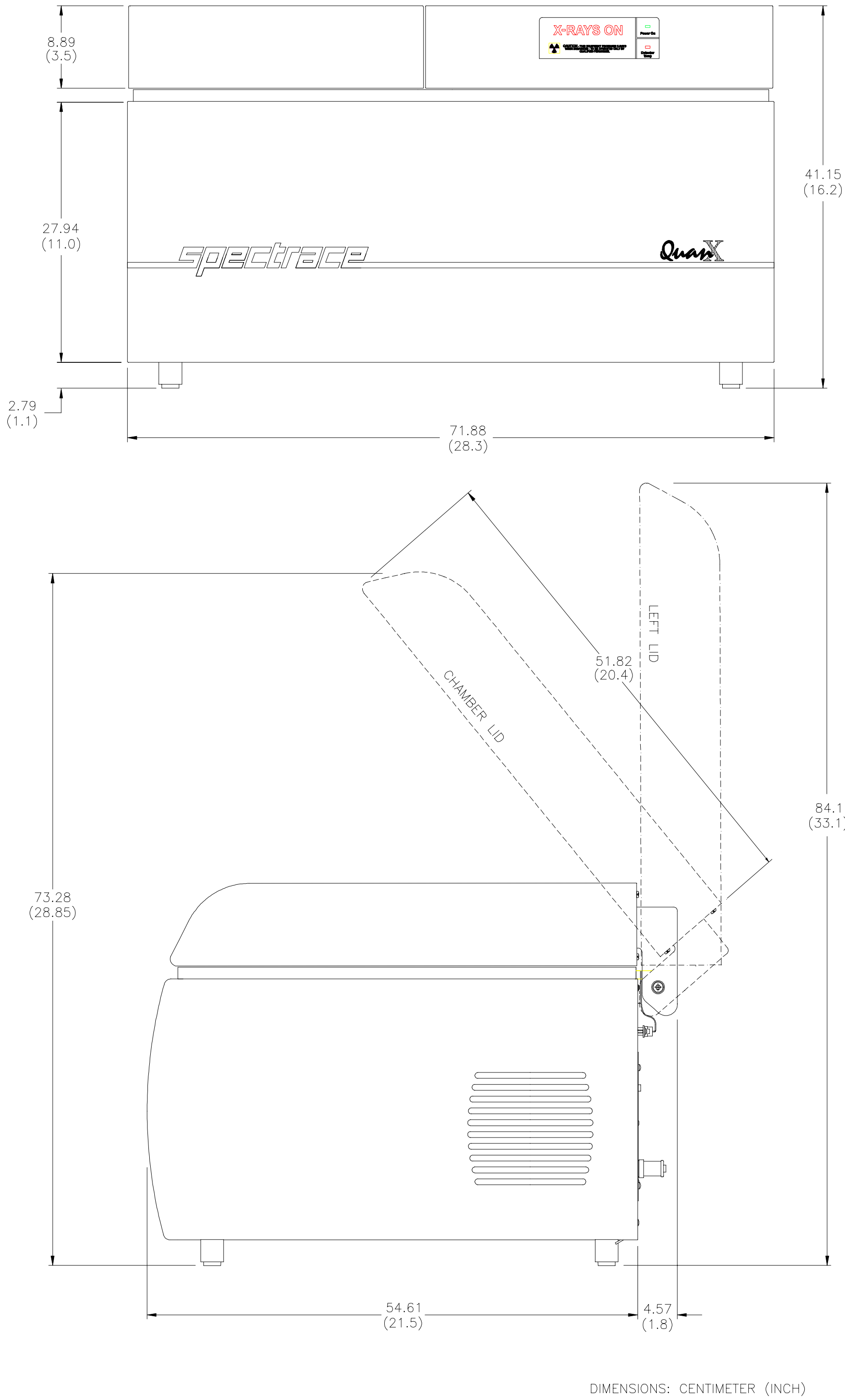

Figure 3-7 Physical dimensions, front and right side view.

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4. Theory of Operation

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4.1 Introduction

This section describes selected portions of the QuanX in detail. The presentation consists of descriptions of the various components introduced in Section 3. For most descriptions it is assumed that the reader has the relevant schematic or block diagram at hand for reference.

4.2 X-ray Tube

The source for illuminating the sample with X-rays is the X-ray tube, shown schematically in Figure 4-1. The tungsten filament is heated by a pulse width modulated AC current from the X-ray control board. The heated filament cathode emits electrons which are attracted to the anode by a positive potential. During transit they gain energy from the electric field which exists between the anode and cathode. When the electrons strike the anode, they lose this energy by producing both X-rays and heat. A focusing electrode causes the electrons to impact the anode in a spot about $1mm^2$. The magnitude of the electron current is controlled by the X-ray control board, and is limited to 1.98 mA.

The anode, also called the target, consists of a thin disk of rhodium or other material plated on a copper block.. The anode is typically cut such that the angle between the face of the target and the normal to the exit window is 20°. The window is made of thin (0.005") beryllium foil, which allows X-rays to escape and at the same time holds a high vacuum.

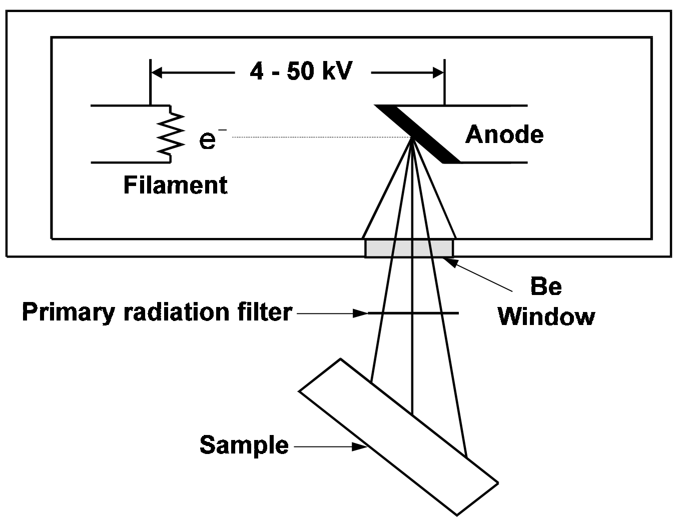

Figure 4-1 X-ray tube schematic

Use of the X-ray tube in quantitative analysis requires attention to the following three considerations:

It is important to measure the spectrum from the X-ray tube to make sure that the correct target material is used. This can be done by observing the scattered spectrum. The characteristic K and L lines of the target should be present.

Slight changes occur in the position and dimension of the filament and other internal dimensions as the tube warms up to its equilibrium temperature. These changes may affect the intensity distribution of the primary beam. It is thus important to wait half an hour at operating voltage and current before making precise quantitative measurements.

The output flux of the X-ray tube at constant kV and mA decreases approximately 3% for each 1000 hours of operation due to pitting and sublimation of target material on the inside of the tube window. To obtain accurate results, this effect should be calibrated out.

4.3 X-ray Control Board

The X-ray control board, part number 5911-0220, (schematic no. 5919-0161) controls the voltage and current applied to the X-ray tube. It is able to control both 30kV and 50kV X-ray power supplies for currents up to 1.98 mA.

Control Interface

Tube current and voltage settings are transmitted to the X-ray control board via a 3 wire serial interface. The three lines WRI, STR, and DATA connect to optoisolators U3, U4, and U5, respectively. Information is sent as 8-bit words with the most significant bit (MSB) first. The MSB indicates whether the word is a current or voltage value, the other seven bits are the value. A pulse occurs on the STR line for each bit and clocks the DATA signal into serial-to-parallel converter U7. When all eight bits have been received, a pulse on the WRT line latches the output of U7 into the appropriate DAC. U8 is the voltage DAC and U10 is the current DAC.

Current Control

In an X-ray tube, electrons flow from the filament to the target where they produce X-rays upon impact. The magnitude of the current depends on the temperature of the filament. An AC current from transformer T1 heats the filament. A pulse width regulator U1 controls the AC current by varying the width of the pulses used to drive the transformer. The regulator has a feedback path designed such that U1 heats the filament to cause a current flow to the tube target (anode) equal to a reference current established by control DAC U10. This reference current is produced by the circuit consisting of Q3, R26, U10 and U11.

When the high voltage supply is off, relay K1 switches the feedback to a second circuit whose output is proportional the pulse width of the AC drive. This causes U1 to supply a small amount of AC current to the tube filament to keep it warm.

Voltage Control

The output voltage of the high voltage power supply is controlled by varying a voltage to its control input. There is a linear relationship between these two voltages. The control voltage is derived from a reference voltage provided by the high voltage supply. This reference voltage corresponds to the supply's maximum output voltage. For example, if a reference voltage of 10V is provided by the power supply then applying 10V to the supply’s control input will cause its output to be at maximum (30 or 50kV). Applying half the reference voltage generates half the maximum output (5V control ⇒ 25kV output for 50kV supply) and so on. Voltage control DAC U8 determines the percentage of the reference voltage that is connected to the control input.

The circuit that generates the control voltage consists of Q4, U8, and U9. The reference voltage from the power supply is used as the analog input voltage for digital to analog converter U8 after being buffered by half of U9. The digital input to U8 determines what fraction of the analog input voltage is output by U8. This output is amplified by the other half of U9 and by Q4 to produce the control voltage. The gain of this amplifier is switch selectable for either 30 or 50kV systems. This is necessary since full scale output of the DAC is a smaller percentage of the analog input voltage on 30kV systems than on 50kV systems. The gain is increased on 30kV systems so that a 30kV setting produces a control voltage equal to the reference voltage. R30 and R33 are gain trims for the two ranges.

Interlocks

Interlocks are designed to prevent operators, technicians or bystanders from being exposed to X-rays. Connectors J3 and J5 on this board carry interlock signals and power for the X-ray high voltage power supply. The interlock circuit is described in the following section.

4.4 Safety Interlock Circuit

Refer to drawing number 0110-0632, SAFETY INTERLOCK CIRCUIT, for a block diagram of the interlock circuit. The QUANX BLOCK DIAGRAM, drawing 0150-0112, gives the part numbers of the various boards and cables involved.

Safety Features

The safety features implemented by the interlock circuit provide protection against the X-rays being turned on when a potentially unsafe condition exists. In particular, the interlocks provide the following features:

- All interlocks must be closed for the X-rays to turn on. If any of the interlocks is opened, the X-rays are turned off immediately.
- The X-RAYS ON warning light must be on for the X-rays to turn on.
- If the interlock circuit is broken, the X-rays do not turn on again until the interlocks are closed and the analysis sequence is reinitiated by the operator.
- The current that powers the X-ray high voltage power supply flows through most of the interlock circuit. Thus if the circuit is broken at any one of the interlocks, there is no power to the X-ray tube regardless of the status of the logic circuits monitoring the interlock condition.
- The circuit is designed so that failure of any of the electrical components can only cause the X-rays to turn off, not to turn on.
- Every time the sample chamber lid is opened, its interlock switch is tested for proper operation by a local microprocessor.
- The sample chamber lid has two interlock switches with separate circuits and mechanical actuators.
- The sample chamber lid primary interlock switch uses a *Positive-Break* (➲) design; the contacts are forced open by a mechanical drive mechanism rather than by a spring as in a normal switch. It also features a bypass-resistant actuator which requires a unique-geometry actuator key to close the contacts.

Interlock Circuit

The circuit starts with +24 volts at the output of power supply PS2 located on the power supply tray. The +24 volts is carried by cable 5101-0273 which connects to the X-ray control board (schematic 5919-0161) on J2 pin 1. The +24 volts exits the X-ray control board on J3 pin 4 and is routed in series through all of the interlock switches and returns on J3 pin 3. The interlock switches are located on the chamber detector and X-ray tube ports, the sample chamber lid, the left cover, and the enclosure cover. The switch connections are part of cable 5101-0375. The +24V is then passed through a jumper in the X-ray tube filament cable connector J5 pins 4&5 to prevent generation of high voltage if the X-ray tube is disconnected. From there, the +24V exits the X-ray control board again on J3 pin 2 on its way to the chamber control board (schematic 5911-0217) where the X-rays on/off control is accomplished.

The signal enters the chamber control board on J1 pin 7 and is named INTERIN. It passes through relays K1 and K3 to turn on the X-rays. K1 is controlled by logic circuits which monitor the voltage level of INTERIN, the status of the X-RAYS ON light, and the status of the “lid closed” and “lid locked” switches located on the chamber lid latch assembly (8100-7407). The logic circuit will not energize relay K1 unless the computer issues an "X-ray on" command, *and* the INTERIN signal is at +24 volts (switches are all closed), *and* the X-RAYS ON light is actually illuminated, *and* the chamber lid is closed and locked. Relay K3 forms part of the second, redundant chamber lid interlock circuit. It is controlled only by the “lid closed” and “lid locked” switches located on the lid latch assembly. Note that these switches operate on an independent +5V logic signal, they are not part of the +24V primary interlock loop. Anytime the chamber lid is closed and locked, K3 is energized. In this condition K1 serves to turn the X-rays on and off in response to computer command. K1 and K3 are wired in series so that if either one is open the X-rays will not be generated.

Once the +24 volt signal passes through relays K1 and K3, it is named INTEROUT and leaves the chamber control board on J1 pin 54. This voltage is connected again to the X-ray control board on J3 pin 1 where it is routed directly to J4 pin 1. From J4 pin 1, cable 5101-0378 carries the +24V to the X-ray high voltage power supply and X-rays are generated.

Note that the +24V supply that powers the high voltage power supply actually passed through all the interlock switches. This fail-safe design insures that even if the logic or control circuit fails "on," any entry into a potentially hazardous area by an operator or technician will automatically stop the generation of X-rays.

Self-monitoring Diagnostics

Three mechanisms are employed to automatically detect interlock or control failures and alert the system operator. One is a system level check performed by the QUANX program and the others are hardware checks performed locally in the QuanX itself.

To verify that the control circuits are functioning correctly, the INTEROUT voltage is monitored by the analysis program running on the personal computer. Every time an acquisition is completed and the X-rays are turned off (K1 and K3 de-energized), the computer reads a chamber board signal named CONFIRM. This logic signal is generated by the INTEROUT voltage (output of relay K3) which should be zero when the X-rays are off. If the computer determines that the X-rays are on when they should be off, an error message is displayed on the computer display and continued operation of the system is not allowed. The CONFIRM signal is also checked every time an acquisition is started and the X-rays are turned on. This is done primarily to alert the operator if the X-rays fail to turn on for some reason, but also serves to test the function of the CONFIRM signal circuitry so that a fail in the “X-rays are off” state is detected.

The second diagnostic function monitors the operation of the primary sample chamber lid interlock switch. When the chamber lid is open, two signals are generated: a “lid open” signal generated by the switch located on the lid latch assembly, and an “interlock open” signal generated by the primary interlock switch. The microprocessor located on the chamber control board continuously monitors the state of these two signals. If ever a state exists such that the lid is open and the interlocks are *not* open, an error condition is logged and saved (even after the lid is closed again). The next time an analysis is attempted, an error message is displayed and continued operation of the system is not allowed.

The third function is a fail-safe fallback condition. Before the sample chamber is unlocked, the chamber board microprocessor reads the CONFIRM signal to check that the X-rays are off. If the X-rays are not off, several more attempts are made to turn them off. If they are still on, the X-ray tube power is reduced to zero and then the lid is unlocked. Of course the chamber lid interlock switches will also stop the generation of X-rays immediately when the lid is opened. The operator is notified by the analysis program as described above.

4.5 Electrically Cooled X-ray Detector (ECD)

The X-ray detector provides the means for sensing fluoresced X-ray photons and converting them to electrical signals. The detector assembly consists of a Si(Li) detector which is the X-ray sensing device, a vacuum tight housing, an ion pump to maintain a good vacuum, and thermoelectric coolers to cool the Si(Li) detector to its operating temperature.

The Si(Li) detector shown in Figure 4-2 is made from a high purity silicon crystal. A bias voltage is applied to electrical contacts on opposite sides of the crystal to produce an electric field throughout the crystal volume. When an X-ray photon enters the active region of the detector, electron-hole pairs are created by the process of photo-ionization. These mobile charges are collected at the contacts by the action of the electric field which pushes the electrons to the signal contact and the holes to the Schottky barrier contact. This collected charge is the sensor's output signal and is connected to the gate of the FET for amplification. Since an electron-hole pair is produced for each 3.8 eV of photon energy, the signal amplitude is proportional the photon energy. The guard ring contact, which surrounds the signal contact, intercepts surface leakage current which would contribute noise to the output signal.

A set of cascaded thermoelectric coolers is used to cool the Si(Li) detector to a temperature of -85°C. At this temperature, noise produced by thermally generated electron-hole pairs within the detector is virtually eliminated. Thermoelectric coolers are solid state devices which utilize the Peltier effect to produce cooling. Heat is pumped from one surface to another when a DC current is passed through the device. Since this heat is transported by electrical charges, there are no moving parts which can wear out or cause vibration. The detector, FET, and a temperature sensor are mounted in the stack assembly which attaches to the cold side of the coolers. Their hot side is attached to an external cooler and its hot side is connected to a heat sink outside the housing. The detector's temperature is maintained at a constant level by varying the drive current to the external cooler.

The X-ray detector, FET, and internal coolers are contained within a housing which is evacuated to a high vacuum in order to eliminate heat loss due to gas conduction and to prevent contamination of the detector crystal. This assembly is shown in Figure 4-3. This vacuum is maintained by the continuous operation of an ion pump. The pump contains a cathode made of titanium and an anode. A 3 kV DC potential on the anode causes gas molecules inside the pump to ionize. These positively charged ions are accelerated into the cathode where their impact causes titanium to sputter onto the walls of the pump. Titanium is very reactive and chemically unites with active gases to form compounds which adhere to the walls. Noble gases, which are non-reactive, are pumped by burial under the sputtered titanium. The gas ionization process is enhanced by means of an external magnet which causes high energy electrons from previous ionizations to move in spiral paths, thus increasing their chance of striking another gas molecule and creating another ion.

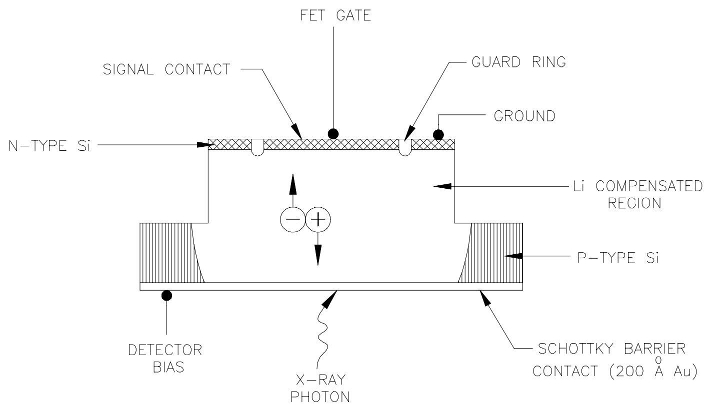

Figure 4-2 Si(Li) X-ray detector for the ECD

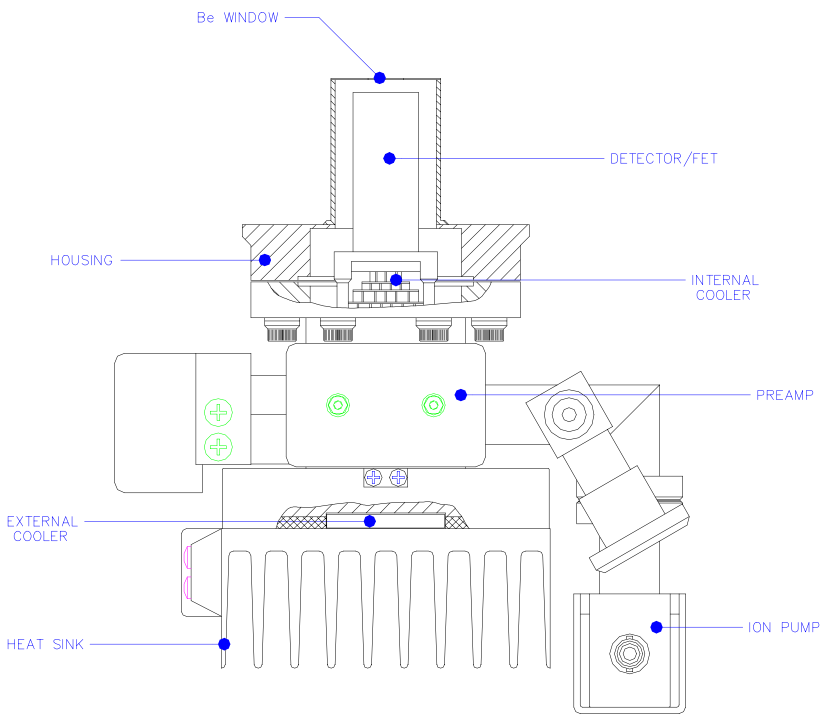

Figure 4-3 ECD X-ray detector assembly

4.6 Liquid Nitrogen Cooled X-ray Detector

The X-ray detector provides the means for sensing fluoresced X-ray photons and converting them to electrical signals. The detector assembly consists of a Si(Li) detector which is the X-ray sensing device, a vacuum tight housing, liquid nitrogen to cool the Si(Li) detector to its operating temperature, and a dewar to hold the liquid nitrogen.

The Si(Li) detector shown in Figure 4-4 is made from a high purity silicon crystal. A bias voltage is applied to electrical contacts on opposite sides of the crystal to produce an electric field throughout the crystal volume. When an X-ray photon enters the active region of the detector, electron-hole pairs are created by the process of photo-ionization. These mobile charges are collected at the contacts by the action of the electric field which pushes the electrons to the signal contact and the holes to the Schottky barrier contact. This collected charge is the sensor's output signal and is connected to the gate of the FET for amplification. Since an electron-hole pair is produced for each 3.8 eV of photon energy, the signal amplitude is proportional the photon energy.

The liquid nitrogen dewar shown in Figure 4-5 is an extremely well insulated, double walled vessel. The space between the vessels is lined with super-insulation and is evacuated to a high vacuum in order to eliminate heat loss due to gas conduction. A cold finger extends from the inner vessel to the stack assembly which holds the Si(Li) detector crystal and FET. The cold finger and stack assembly are under the same high vacuum to prevent heat conduction and to prevent contamination of the detector crystal. The detector crystal operates at liquid nitrogen temperature (-196°C), however the FET temperature is raised slightly with a heater resistor to reduce electrical noise.

The vacuum inside the dewar is maintained by activated carbon, a type of molecular sieve or getter. Due to its processing, the carbon presents a very large surface area and is highly adsorptive when cooled to low temperatures. It acts as a “sponge” to adsorb gas molecules which remain bonded to the surface as long as the low temperature is maintained. After several years the carbon becomes saturated and the dewar must be reevacuated.

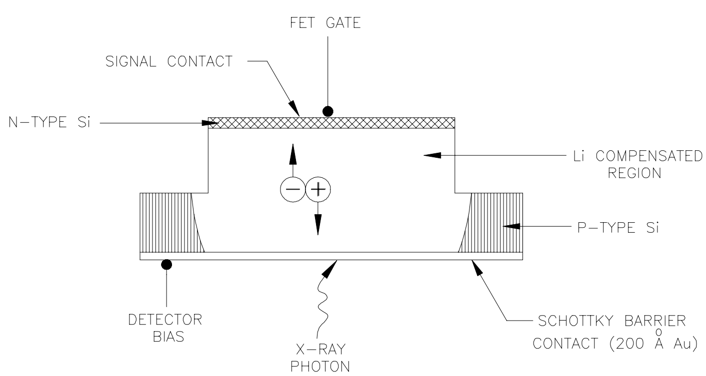

Figure 4-4 Si(Li) X-ray detector for the LN model

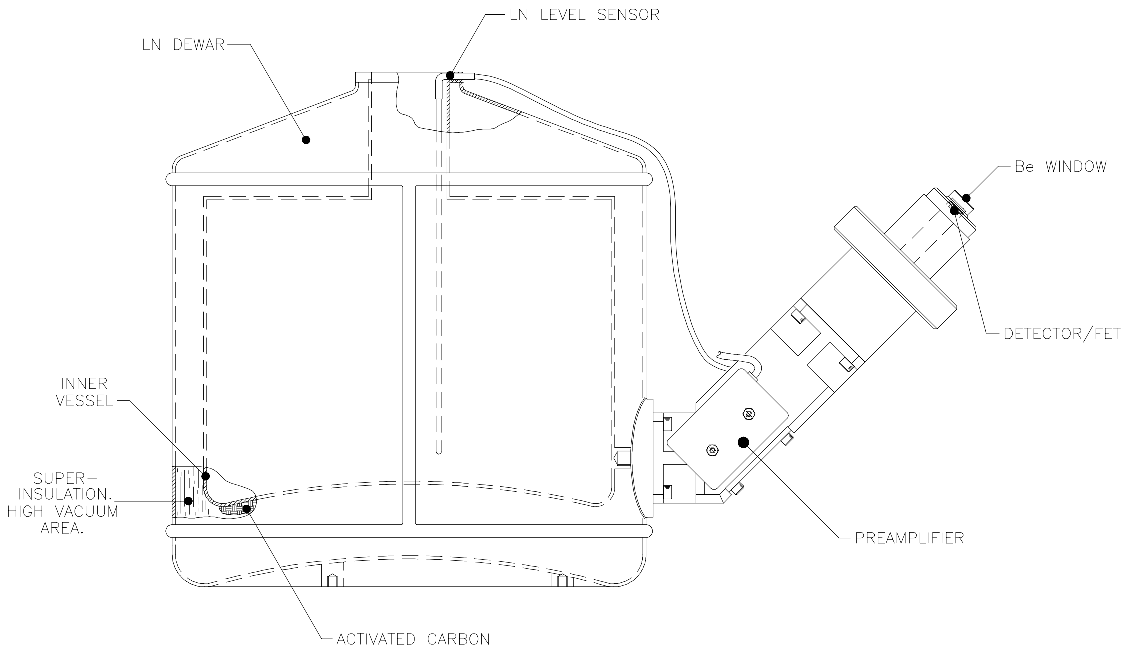

Figure 4-5 LN X-ray detector assembly

4.7 Preamplifier

The pulsed optical preamplifier and related components are shown in Figure 4-6 and schematic 0110-0609. The FET and the amplifier are in a negative feedback configuration. C_f acts as the integrating capacitor so output A is proportional to the integrated charge. Detection of an X-ray photon will produce a fast positive step in the output. The amplitude of this step is proportional to the photon's energy. Since the X-ray flux from the sample consists of many photons with varying energy, the preamp output looks like a stair case with varying step heights.

In order to keep the preamplifier's output within its linear range, a pulsed optical feedback loop is used. When the output exceeds zero volts, an LED inside the detector assembly is pulsed on. Light striking the FET induces current to flow from its drain to gate. This current removes the charge which has accumulated on the gate and resets the output to a negative voltage.

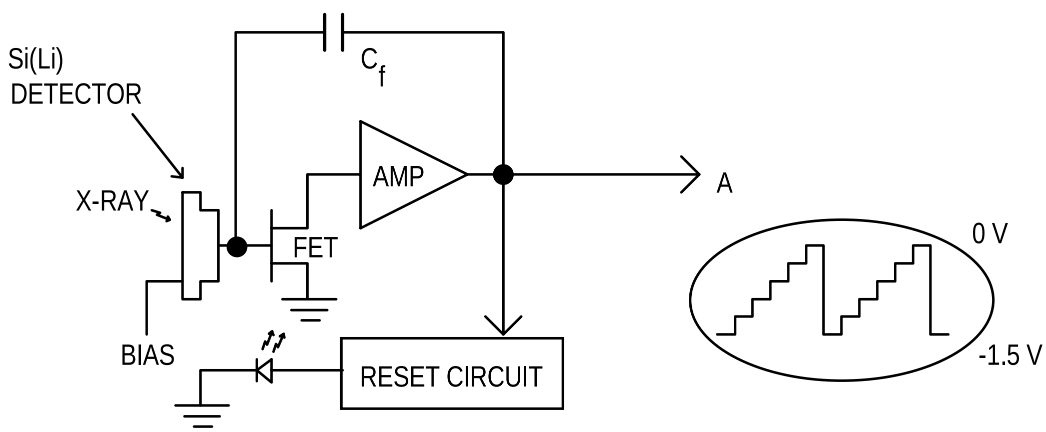

Figure 4-6 Pulsed optical preamplifier and FET

4.8 Chamber Control Board

The part number of this board is 5911-0217 and the circuit is shown in schematic no. 5919-0217.

Overview

The chamber control board is responsible for all machine functions, some of which include:

- Monitoring safety interlocks
- Communicating with the personal computer
- Setting the X-ray tube power
- Controlling the chamber atmosphere
- Driving the stepping motors for the sample tray and filter wheel

The board is based on an 8031 microcontroller. Communication with the personal computer is by means of a 3-wire RS-232 interface using RxD, TxD and GND at 9600 baud, no parity, 8 data bits, and 1 stop bit. The program memory is stored in a 64K x 8 EPROM. An 8282 octal latch is used to separate the address for the EPROM. Two 8255s and a 74LS244 are used to increase the number of I/O lines on the board.

Auto-reset

In order to ensure that the microcontroller will recover from a random error, an automatic reset circuit is used. Should an error cause the auto-reset circuit to be serviced too often or not often enough, the auto-reset circuit generates a reset (RST) to the microcontroller. The circuit senses the voltage on a capacitor C46 being charged to +5V. Either one of two comparators will generate RST if the voltage on C46 is too high or too low. A third comparator sends AZRO to the microcontroller to indicate that the reset circuit requires service. Service consists of AZRI being sent to the reset circuit, which discharges capacitor C46.

Initialization

The board will carry out an initialization procedure every time the power is first turned on or any time the auto-reset circuit generates a RST signal. The initialization process is controlled by the program stored in the EPROM U19 and does not require the personal computer. The board will not communicate with the personal computer until the entire initialization process has been successfully completed. The major steps are listed in the order performed:

- Configure I/O ports including RS-232 settings and 8255 configuration.
  Sets X-rays off, lid latch open, ECD coolers on, baud rate, etc.

- Initialize the filter wheel.
  Locate the home flag via the optical sensor. If it fails to find home, set an error bit and continue.

- Initialize the sample tray (if installed) or the linear motion for R-Theta or X-Theta stage (if installed).
  Locate the home flag via the optical sensor. Failure to locate the sample tray home stops the initialization process. Theta stage failure sets an error bit and initialization continues.

- Initialize the R-Theta or X-Theta rotation axis (if installed).
  Locates the home flag via the optical sensor. Failure to find home sets an error bit and initialization continues.

The initialization using the optical sensor involves locating both edges of the home flag and then centering the flag in the sensor. This can be observed as the device, for example the sample tray, rotates one direction, reverses direction as required to locate the flag edges, and stops.

If an initialization error bit was set, a warning message will be displayed on the computer when the QUANX program is started.

Stepping motor control

The board can control four stepping motors. One to turn the filter wheel, another for the sample tray (or Theta stage linear motion), the third for the Theta stage rotation axis, and the fourth for the sample spinner drive. All the motors are 2-phase, uni-polar configuration. The sample tray drive and Theta stage each short a signal line (/TRAY IN, /THETA IN) to ground when it is plugged in. This informs the microcontroller of its existence. The circuits used to drive all but the spinner motor are identical. The motor windings are driven by MOSFET transistors with signal names FD1-FD4 (filter), SD1-SD4 (sample tray), TD1-TD4 (theta/spinner). The inverters serve to buffer the signals from the 8255 and raise the FET drive voltage to +12V.

The sample spinner and Theta stage options are never installed simultaneously and so are able to share a single set of driver transistors (Q10,11,19,21). Switches SW1 and SW2 select which control signals are routed to the transistors. The sample spinner motor doesn't require position control so U4 is used to generate the motor signals; the microcontroller can only start and stop it via the /OE pin.

The home sensors are read from the FHD (filter home detect), SHD (sample tray), and THD (theta) inputs. These signals are logic high when the home flag is inside the optical sensor, and low otherwise. LEDs D9-11 give a visual indication of the home status for troubleshooting purposes (on=home).

Vacuum sense and control

The status of the vacuum is determined using a thermocouple vacuum sensor mounted in the chamber. It contains two crossed wires. One of the wires is heated with an AC current, resulting in a DC voltage between the two wires due to the dissimilar metals junction. As the vacuum increases, there are less gas molecules to conduct heat away from the junction and its temperature, and hence the DC voltage, increases. The AC current is supplied to the vacuum sensor by transformer T1. U2 generates a square wave which drives T1 via Q14. Voltage regulator U34 is used to adjust the voltage supplied to T1, which regulates the AC current to the sensor. The op-amp U33A amplifies the signal from the vacuum sensor by 100, filters it, and U33B acts as a comparator to generate the /VACUUM OK signal when the TP11 voltage falls below the TP2 voltage set by SW3. SW3 is used as a simple means of calibrating the board to the individual sensor, which is required because the sensor output varies from one to the next. A switch is used so that a replacement board may be easily calibrated by matching the switch setting to the original board. The OK trip point is set for 750-1000 mTorr. VR3 is used to null the U33A input offset voltage. R150 and R144 are used to bias the entire input stage slightly positive for noise rejection and single supply op-amp operation. The sensor output (TP12-TP10) changes by about 3mV from atmosphere to 750 mTorr. LED D1 is a visual indication of the /VACUUM OK signal (on=OK).

X-ray tube power control

The board controls the X-ray tube voltage and current via a 3-wire serial interface to the 5911-0220 X-ray control board. The three control lines are DATA, WRI, and STR. The data is sent over the DATA line, most significant bit (MSB) first. The MSB selects either the voltage or the current control DAC. The other seven bits set the value of the selected DAC. The STR signal indicates a new bit. The WRI signal writes the value into the DAC.

Communication with the computer

The microcontroller communicates with the personal computer over the RS-232 serial interface using ASCII character codes. The board has a predefined instruction set based on the version of EPROM installed. Different EPROMS are required for option support, such as the R-Theta sample stage. A typical control communication sequence is as follows:

> The PC will issue a command, for example to move the filter wheel; the board will echo back the same command characters as confirmation of receipt, execute the command, and send a carriage return (CR) when the execution is complete (filter is in position).

The PC may also query the board for several machine status conditions. The echo/CR protocol is always used regardless of the type of communication.

A program called ECHOA is provided to allow a technician to communicate directly with the chamber board for troubleshooting purposes. See Section 8, Diagnostic Software, for a description of the ECHOA program and a complete instruction set listing.

Voltage measurement

An analog-to-digital converter (ADC) circuit is included to measure all system power supply and critical signal voltages for troubleshooting purposes. U5 and supporting components form the ADC circuit. Multiplexers U6-8 act as selectors to choose which voltage is to be measured, U5 can only measure one at a time. The selection is made via the VS0-VS2 and /VCS0-/VCS2 chip select signals issued by the microcontroller U17 via 8255 U14 and decoded by U13B.

Most of the voltages must be conditioned before presentation to the ADC because its input must be positive and no larger than 1.999 volts. Conditioning utilizes a voltage divider network and/or polarity inversion using op-amps. The X-ray tube current is measured by a differential amplifier circuit formed by U10A and supporting components. This circuit measures the voltage generated by the tube anode current flowing through a resistor on the X-ray control board.

The output of the ADC (ADC0-3) is read by U14 and transmitted to the PC over the RS-232 link, where it is multiplied or divided as required to restore the correct decimal place position (magnitude) and polarity.

A thermistor, TR1, is part of a voltage divider which generates a voltage that is a function of temperature. This voltage is called AMBIENT and is measured by the ADC so that the internal enclosure temperature may be remotely monitored by the PC.

I/O lines and device control

The 8255s U14 and U15 are configurable for use as input or output ports. The configuration is set during board initialization and is as follows: U14 port A = output, port B = input, port C = output; U15 port A = output, port B = input, port C = output. The 8255s are selected by chip select signals /CS0-2 decoded by U13A from DATA/CS and SELECT. DATA/CS is a shared signal line, it is used for 8255 addressing and for X-ray tube voltage and current data. These functions are never carried out simultaneously so the line may be shared. U16 is a dedicated input port.

The lid latch, chamber vent valve, and the two helium valves are switched on and off by MOSFET transistors Q18, Q7, Q16, and Q6, respectively, which provide a ground path for the device solenoid (the other end of the solenoid is connected to a power supply). The vacuum pump is controlled by Q5 which drives a solid-state relay located in the AC distribution box.

Interlocks

The overall system interlock circuit is described in Section 4.4, Safety Interlock Circuit. This discussion will focus on the chamber board circuits only.

There are two microswitches on the sample chamber lid latch assembly, one is actuated when the lid is closed and the other senses the motion of the locking solenoid shaft. When the lid is closed *and* locked, U22A and D are both low (/LID CLOSED & /LID LOCKED) which generate a high LID OK. This energizes relay K3 via Q3. The "lid closed" switch and K3 form an independent, redundant chamber lid interlock circuit which is not the primary means of protection and control.

To explain the primary interlock and control circuits, a typical X-ray turn-on sequence is described.

When all the interlock switches are closed, +24V will be present at J1-7, referred to as INTERIN. This signal is buffered and level tested by comparator U9D which generates a signal called INTERLOCK (if INTERIN is at 24V) and enables operation of flip-flop U20. When an /X-RAY ON command is received, U20 pin 6 goes low and relay K2 is energized. A flip-flop is used so that a new /X-RAY ON command is required to restart the X-rays after an interlock has been broken.

The output of relay K2 is then at +24V and is called ENABLE LAMP. This voltage does two things. First it powers the "X-RAY ON" warning sign located on the 5911-0218 display board. Second it provides power for the coils of relays K1 and K3 so that they may be energized later. The coils are wired this way so that the relays can't be energized (such as by a failed drive circuit) unless the computer has issued an X-ray on command.

The return current from the warning light (powered by ENABLE LAMP 24V) flows through R112. The voltage generated is tested by U22B and C. If the voltage is lower than LOW REF (warning light is off or only partially on) or if the voltage is above HIGH REF (warning light LED segment is shorted) then the X-rays will not turn on. If the voltage is within the correct range then U25 pin 11 will go high and if the LID OK signal is high (lid is closed and locked) then K1 is energized and the X-rays turn on. In detail, the INTERIN voltage (from the interlock switches) goes through K1 and then through K3 and out J1-54 where it is called INTEROUT. This voltage is the power source for the X-ray high voltage power supply. So the interlock switches and relays K1 and K3 are all in series and must be closed to route power to the H.V. block.

The INTEROUT voltage is divided down and buffered to become a logic level signal called CONFIRM. This signal is read by the computer and the chamber board EPROM program to determine if the X-rays are actually on or off.

A series of LEDs is included at each step of this sequence for troubleshooting purposes. The LED names, which are self explanatory, are: D8 LID CLOSED, D6 LID LOCKED, D3 INTERLOCK IN, D5 ENABLE LIGHT, D4 LIGHT ON, and D2 INTERLOCK OUT. Also, a logic level signal is available to the microcontroller at each step of the process so that automatic troubleshooting assistance can be provided in the form of operator error messages.

4.9 Display Board (X-ray On Warning Light)

The part number of this board is 5911-0218 and the circuit for this board is shown in schematic 5919-0218.

This board illuminates the X-RAY ON warning light, the Power On light, and the Detector Temp light. Each are described below.

The primary component of this board is the LED luminator D1. This device uses 8 red LED segments shining light into the edge of a plastic body. The plastic is treated for maximum optical reflection. The LED segments are wired as 2 parallel branches of 4 LEDs in series. They are powered by a signal from the 5911-0217 chamber control board. The current through the LEDs is monitored by the chamber board as part of the interlock circuit so a regulator, U1, is used to eliminate sensitivity to input voltage variations. R6 is an adjustment to set the current through the luminator, which vary from unit to unit due to the LED forward voltage drop. Failure of any segment, whether open or short, will prevent X-rays from being generated.

CAUTION
The luminator D1 is susceptible to damage from the heat of soldering. The maximum rated temperature for soldering is 500°F for 3 seconds.

The green Power light, D2, is on anytime the instrument power switch is on.

The red Detector Temp light is a flashes when the LN detector LN level is low, or when the ECD detector is above normal operating temperature. The flasher circuit is on the chamber control board.

4.10 Bias Supply Board

The circuit for this board is shown in schematic 5919-0189. The board consists of a detector bias supply, a FET protection circuit, and a liquid nitrogen level, or detector temperature, monitor.

Two versions of this board are used. The LN detector version is part number 5911-0196 and the ECD version is 5911-0194. They differ only in the bias voltage setting and the low LN alarm circuit characteristics.

Detector bias supply

The heart of the bias supply is a bridge oscillator whose amplitude is voltage controllable. This oscillator, consisting of amplifier U5 and its associated components C20, C23, R34, and R43, determines the operation frequency, which is nominally 25-30 kHz. The oscillation amplitude is determined by the feedback network consisting of CR5, CR6, R21, R23, R33, and Q1. A variable resistor, R20, is used to calibrate the gain of the oscillator to a nominal value. FET Q1 functions as a voltage variable resistor and allows the oscillator amplitude to be varied by a control voltage from the stabilizing feedback network.

Transistors Q8 and Q9 provide the power gain necessary to drive a voltage multiplier circuit, consisting of T1, C2-C8, CR1-CR4, and R16-R18. This circuit converts the oscillator output to -1000 VDC. The desired detector bias voltage is selected by connecting resistor R3 to the appropriate tap on the voltage divider formed by resistors R5-R15. Thus the detector bias voltage is jumper selectable. The default values of this jumper setting are 300V for the ECD and 600V for LN cooled detectors.

U3 and its associated components form a voltage stabilizing feedback network which compares the multiplier output voltage with a reference voltage. Any deviation from -1000 VDC produces an error voltage which changes the oscillator amplitude to correct the deviation. A variable resistor R26 is adjusted to set the output of the error amplifier U3 to its nominal value when the multiplier output is -1000 VDC. Thus the bias voltage is very stable, and has very low ripple.

FET Protection circuit

The protection circuit is designed to guard the input FET against damage caused by system warm-up due to loss of liquid nitrogen, vacuum failure, or by improper system operation and installation. This circuit monitors the detector leakage and disables the detector bias if the current exceeds safe limits, regardless of the origin of the high current. In the ECD version only, a high detector temperature alarm (“low LN” alarm) will also turn off the detector bias.

The magnitude of the leakage current is deduced from the preamplifier reset pulse rate, as it is proportional to the current. The reset pulses are averaged by and R-C integrator, R45 and C35. If this average value exceeds a predetermined limit, the output of U7 switches to zero volts and the output of U6 switches high. A high output from U6 turns off the front panel HV LED and stops the oscillator by switching Q2 on. When the excessive leakage current stops, the output of U7 switches high and U6 provides about a one second delay before the oscillator is restarted.

Liquid nitrogen level monitor

The same circuit is used for low LN warning and high ECD temperature. The board front panel LED is labeled LN LEVEL in both cases and is on when the LN level or ECD temperature is normal, or flashes when the LN level is low or the ECD temperature is high.

LN version:

The liquid nitrogen level monitor provides a visual and an audible alarm whenever the detector dewar needs refilling. When the liquid nitrogen level falls below the sensor, the sensor resistance increases. U8 senses this increase and its output switches high.

A stable oscillator U9 begins to operate and flash the board front panel LN LEVEL LED. The /LLN signal generated from Q4 is connected to the 5911-0217 chamber control board where it may be read by the personal computer and also starts the LED flasher circuit which drives the DETECTOR TEMP light on the instrument front panel. If the ALARM MUTE switch is pushed, Q7 turns off and Q6 turns on. Since Q7 is now held turned off by Q6, the audio alarm is turned off but the both LEDs continue to flash.

When the dewar is refilled, the output of U8 switches low, thus stopping the oscillator U9.

ECD version:

All the circuit functions are the same. The temperature sensor is located on the stack assembly inside the ECD housing so that the board is monitoring the Si(Li) detector crystal temperature. The circuit resistor values are different from the LN version because the alarm trip point is higher for the ECD as it runs well above LN temperature.

Jumper settings

Jumpers E1, E3, and E6 should be installed for the LN version of this board. These settings will cause the FET protection circuit to respond only to high detector reset rate.

Jumpers E1, E3, and E5 should be installed for the ECD version of this board. These settings will cause the FET protection circuit to respond to high detector temperature (“low LN”) as well as high detector reset rate.

4.11 ADC Interface Board

The part number for this board is 5911-0181 for the original version (non-shielded cable) or 5911-0224 for the newer version (shielded cable). The circuit for this board is shown in schematic 5919-0181. The board provides memory for storing the spectra that are being collected. It also provides the communication path between the computer and the analyzer. This board occupies one expansion slot in the computer.

Memory

The data memory is organized as 4K by 24 bits (three bytes). Both the ADC and the computer can access this memory. The ADC accesses it 16 bits at a time, reading or writing to the two least significant bytes. In the computer the contents of this data memory are mapped into its RAM space as a 16Kx8 block. Starting at the beginning of this block, the first three bytes of RAM correspond to the first 24-bit data memory word. The fourth byte does not exist and reading it returns zeros. This pattern is repeated for the entire block of RAM one byte at a time.

Since both the ADC and the computer can access the data memory, a bus arbitration circuit is used to prevent them from accessing it at the same time. When the ADC access the data memory, it generates a memory request and then waits until it receives a grant from the arbitration circuit. When the computer accesses the data memory, the I/O CHANNEL READY line goes low, causing wait states to be generated until the arbitration circuit sets it high again. Whichever has access to the memory will continue to have access to the memory until completion of the read or write cycle. When both the ADC and the computer try to access the memory within one clock cycle, the ADC is granted access first.

When the ADC reads or writes the two least significant bytes of the data memory, the most significant byte is latched into a register or written into the memory from the same register. This register is located in the ADC I/O space.

When the computer reads the least significant byte of the data memory, the two most significant bytes are latched into a pair of registers. These two registers are read when the computer reads the next two memory locations. When the computer writes the least significant byte of the data memory, the two most significant bytes are written into memory from two different registers. These two registers are written to when the computer writes to the next two memory locations.

Communication

The ADC and the computer communicate with each other through registers located in their I/O spaces. The ADC uses interrupts for handshaking; the computer employs polling.

Whenever the computer sends a command to the ADC, it writes two bytes, which represent the command, into a pair of registers. This generates an interrupt to the ADC that tells it the computer has a command for it. The interrupt is cleared when the ADC reads the two bytes. The computer will write into the registers only after it has determined that the interrupt has been cleared.

Whenever the ADC sends data to the computer in response to a command, it writes two bytes into another pair of registers. This sets a bit in a register the computer uses for polling. When the computer sees that this bit is set, it reads the information sent to it. This action clears the bit that was set. The ADC also sends status information to the computer. This is a byte written to its own register and sets its own polling bit.

4.12 ECD Control Board

The part number of this board is 5911-0207 and the circuit is shown in schematic 5919-0207 (references to the model 8000 apply to the QuanX). This board is responsible for regulating the ECD temperature, protecting the ECD from damage, generating alarm signals, and supporting the ECD ion pump.

Power supplies

The board runs on a single +24 VDC power source supplied via J3 pin 6. Three voltage regulators, U6-8, are used to generate local supply voltages. U8 is adjusted to +12V output by R41. This supply is used to operate the integrated circuits on the board. U7 is set for approximately +14.3V output by R40 and is used to charge the ion pump backup battery. The battery charging voltage is +13.6V after the D3 diode drop. U6 is fixed at +12V output and is used to operate the ion pump when the instrument power cord is plugged into an AC power source.

Connector J2 is not used in the QuanX.

Ion pump support and monitoring

The ion pump is powered by U6 under normal operating conditions. The power leaves the board on J5 pin 4, relay K2 is energized and so has no affect. When the instrument power cord is unplugged, the backup battery power enters the board on J5 pin 3, goes through K2, and out J5 pin 4 to the ion pump power supply.

The voltage for the ion pump power supply is also a signal called IPP which is connected to comparator U1 to generate the /ION PUMP ON signal which is read by the computer. The ion pump power supply has a current monitor output which generates a voltage proportional to the ion pump current (1mV = 1µA). This voltage is amplified by U5 and then connected to J1 pin 8 for measurement by the chamber board ADC circuit and also is connected to comparators U3 and U1 to generate an alarm signal.

The ion pump current signal is also used in an auto-defrost circuit. Over a long period of time, gas molecules will collect on the cold internal components of the ECD. When the ECD is warmed up to room temperature, the molecules become mobile and in severe cases can overload the ion pump. The auto-defrost cycle is initiated by turning off the coolers via the signal /TURN OFF COOLERS (J1 pin 11, low=off). This is a software controlled signal from the chamber control board. It turns off the coolers via U3 pin 1 to U2 pin 1. If the ion pump exceeds 300µA, U2 pin 13 goes low which turns the coolers back on (the LM339 comparators have open collector outputs). Once the ion pump current has dropped, the coolers are turned off again. This cycling continues until the pump current stays below 300µA. The QuanX ECD has extremely low leakage and gas buildup is rarely a problem. Therefore, software control of the coolers is not provided in the QUANX analysis program. It is possible to initiate a warm-up by software by using the diagnostic program, ECHOA, described in Section 8 of this manual. Note that turning off the coolers by switch SW1 does not initiate the auto-defrost cycle.

Temperature regulation

The ECD has two sets of thermoelectric coolers. They are referred to as the *internal coolers* (inside the vacuum) and the *external coolers* (outside the vacuum). The internal coolers operate at a fixed power level at all times. The external cooler power is varied to maintain temperature regulation of the Si(Li) detector crystal. The actual point of regulation is referred to as the *base*.

The internal cooler power enters on J3 pin 8 and passes through relay K1 then out to the ECD on J4 pin 3. K1 is controlled by SW1 which is the primary means of turning the ECD coolers on and off. The internal cooler voltage also goes out J1 pin 14 to be measured by the chamber control board ADC circuit. The internal cooler power adjustment is made at the cooler power supply PS5.

The external cooler voltage is varied by utilizing the sense input provided on PS5. An offset signal is generated by U4 which is connected to one side of the R2-R3 resistor divider network. The other side is connected to the supply output. The power supply will vary its output until the output of the divider (connected to the sense input via J3 pin 3) equals an internal reference voltage. This causes the power supply to raise or lower its output voltage in response to the U4 output. The U4 output is derived from the temperature of the base via a NTC thermistor mounted to it. The thermistor forms half of a voltage divider with R1 as the other half. The output voltage is buffered by half of U4 (increase in temperature = drop in U4 pin 7 voltage). R5 is used to set the detector temperature by changing the U4 output voltage.

The external cooler voltage is also routed through K1 and goes out to the ECD on J4 pin 4.

Alarms and status signals

Several signals are monitored by the analysis program via the chamber control board. Four LEDs are include on this board to give a visual indication of some of these signals, they are called: DS1 BASE DRIVE OK, DS2 COOLERS ON, DS3 HEAT SINK OK, and DS4 I.P. CURRENT OK. The LEDs are all on during normal operation.

The external cooler voltage rises as cooling demand increases, such as when the ambient temperature increases. Other causes of increased voltage may indicate a problem developing and therefore an early warning signal called /BASE DRIVE OK is provided. This signal goes high when the external cooler voltage is at 7.4 volts or higher, which is about 90% of its maximum value. When this occurs, an operator warning message is displayed. U3 generates the signal by comparing the voltage (X2) with a reference voltage.

The heat sink temperature is monitored using a NTC thermistor mounted to it. The thermistor and R25 form a voltage divider circuit. U5 buffers the output which connects to two points. First, the U5 pin 7 voltage leaves the board on J1 pin 2 to be measured by the chamber board ADC. Second, U3 compares the voltage to a reference. If the U5 pin 7 voltage falls below the reference (high temperature) then U3 pin 2 goes high which turns off the coolers (via U2 and Q1) to prevent the heat sink temperature from increasing further. Also, the signal /HEAT SINK OK will switch states. This signal will go high when the heat sink exceeds 55°C and an operator warning message will be displayed. High heat sink temperature is the only condition that will automatically turn off the ECD coolers.

Test points

Most of the important voltages are present on TP1 for measurement with a voltmeter. These voltages are also connected to the chamber control board via J1 for measurement and display on the PC monitor. Some of the voltages require conversion to provide meaningful information, these are described below.

- TP1-2 Heat sink temperature: $°C = 90.5 - 35.8V + 5.0V^2$ where V is in volts. A typical operating temperature is approximately 33°C, or 2.5 volts.
- TP1-3 Base temperature: $°C = 62.0 - 13.8V + 0.68V^2$ where V is in volts. A typical operating temperature is approximately 20°C, or 3.8 volts.

- TP1-9 Ion pump current: This point is most useful for relative measurements, such as tracking trends, rather than absolute measurements. To measure the true ion pump current a measurement directly across J5 pins 5 and 6 is best, the conversion is 1mV = 1μA.

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5. Installation

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5.1 Introduction

Installation of the QuanX analyzer is a straightforward process which may include hardware and software setup as well as operational testing. The majority of the task is comprised of performance and functionality testing.

This section includes site preparation requirements and cautionary notes which, if followed, will help insure both reliable and stable operation of the QuanX analyzer.

If the personal computer (PC) was supplied by Spectrace Instruments, the steps related to PC configuration may be skipped. However, the reader may wish to scan these sections to obtain an overview of the process for future reference.

The installation process is presented in a hierarchical manner and should be performed in the order presented. For example, the steps required to cool the X-ray detector are presented first so that it will be ready for operation as soon as possible.

5.2 Site Preparation

Attention to the following recommendations will help insure trouble-free operation of the instrument.

5.2.1 Location

The instrument may be installed on a bench top or on a dedicated stand. In either case, the structure should be strong enough to support 200+ pounds (91+ kg) and remain very stable. Any movement of the structure such as wobbling or vibration can not be tolerated. A low traffic area is recommended to prevent bumping or other disturbances while the instrument is in use.

5.2.2 Atmosphere

The beryllium windows of the detector assembly and X-ray tube are susceptible to damage from corrosion. This type of damage is always catastrophic, requiring the complete replacement of the detector or tube. Do not store or operate the equipment in a high humidity (above 80% RH) or a corrosive atmosphere such as a coastal receiving dock, or near a process emitting corrosive fumes.

Please contact our sales or applications staff for recommendations if analysis of corrosive samples is required. This is critical, since caustic fumes can destroy the detector window in a matter of minutes.

Excessive dust or dirt should be avoided. Internal components will become coated with dirt which may lead to overheating. *Electrically conductive particles (such as metal dust) must not be present in the operating environment!* If the instrument is to be operated in a dirty environment, special fan filters must be installed. Please contact your sales person for details.

5.2.3 Space Requirements

The QuanX requires a rectangular area of about 27 by 36 inches (69 by 91 cm) which includes the minimum 4 inch (10 cm) clearance required on each side for the cooling fan inlets; additional free space for samples or supplies is helpful. The area in front of the instrument should be free of obstructions for at least 3 feet (0.9 m) to allow removal of the enclosure cover for servicing. The QuanX requires about 3 feet (0.9 m) of vertical clearance above the table top.

The personal computer and printer also require an area of about 27 by 36 inches (69 by 91 cm). The computer CPU may be installed up to approximately 5 feet (1.5 m) away from the QuanX if it is located on the left side, or up to approximately 3 feet (0.9 m) away if it is located on the right side. To avoid possible electrical noise pickup, the PC monitor should not be placed closer than 1 foot (0.3 m) away from the QuanX.

Refer to Section 3.4 for a dimensioned outline drawing of the QuanX.

Ample room for a vacuum pump and/or helium gas cylinder will be required if vacuum or helium operation is anticipated. The vacuum pump may not be placed on the same table as the QuanX.

5.2.4 Vibration

The instrument is moderately sensitive to vibration. Microphonic noise is generated by capacitive coupling between the internal components of the X-ray detector. The result is degraded resolution which will adversely affect accuracy and precision.

Both the amplitude and frequency of the vibration are important factors. In general, the lower the frequency of vibration, the larger the amplitude required to produce noticeable degradation. A rough rule of thumb is: if you can feel the vibration with your hand, it may be a problem.

Potential sources of vibration are:

- Heavy machinery operating nearby.
- Raised floors with vibrating equipment in the room.
- Other equipment placed on, or in contact with, the table (such as the vacuum pump).
- Very loud noise.

5.2.5 Temperature

The instrument is designed to operate over a temperature range of 32 to 86°F (0 to 30°C) for the ECD version or up to 93°F (34°C) for the LN version. For maximum precision, the room temperature should be stable. Operation over large temperature swings may require restandardization of the instrument to meet sensitive-application precision requirements.

5.2.6 Power Requirements

The instrument may be set to operate on either 115 or 230 VAC, 50/60 Hz AC power. The maximum power required is 350 watts for the LN version and 500 watts for the ECD version. The personal computer and the QuanX should be plugged into the same outlet. The optional vacuum pump requires 700 watts and may be operated from a separate power source; the QuanX has a second power cord dedicated to vacuum pump operation.

The ECD version requires continuous, uninterrupted power. Loss of AC power for more than 72 hours may cause serious damage to the X-ray detector assembly.

A dedicated power line is recommended since it helps isolate the analyzer from electrical disturbances caused by other equipment in the plant. Although internal power filters are employed, this equipment is sensitive to power-line noise. These excess power-line voltages exist at extremely high frequencies and can occur in nanosecond time periods. Both normal mode (line to line) and common mode (line to ground) disturbances can cause a variety of problem ranging from intermittent performance degradation to actual component failure. Due to modern power supply design, moderate voltage variations are tolerated. The use of a *voltage* stabilizer is not generally required, nor recommended, due to the nature of the switching mode power supplies used. The best protection is provided by a low impedance power conditioner/filter designed for use with switching power supplies. A unit of this type may be ordered as optional equipment.

Due to the unpredictable and sometimes intermittent nature of power-line disturbances, diagnosis of a problem can be difficult, costly, and/or cause a serious loss of productive work time. Therefore, a power line conditioner of the proper type is always a wise addition.

5.2.7 Telephone

A telephone within reach of the system should be considered a mandatory site requirement. Eventually service or applications assistance will be required. A telephone at the instrument's location often makes the difference between the quick resolution of a problem or days of downtime because an on-site visit is required. In addition to verbal support, the instrument is supplied with the capability to be remotely operated via modem. This feature is extremely valuable when service or applications help is required. A direct outside line is normally required for modem operation.

5.3 Special Precautions

Beryllium windows

The X-ray tube and ECD detector both have beryllium windows which are extremely fragile and brittle. Since beryllium metal is highly toxic, do not touch or otherwise handle the foil.

DO NOT touch, jar or subject the beryllium windows to mechanical or thermal shock, or to corrosive substances. Do not store the instrument in a corrosive or high humidity environment. When installing, replacing, or working around the X-ray tube and the detector assemblies, proceed with great caution. If analysis of samples emitting corrosive fumes is anticipated, contact our applications department *before* performing the analysis. Corrosive fumes can permanently damage the X-ray detector assembly in a matter of minutes.

Refer to Section 2, Safety, for more information.

Ion pump power, ECD model only

The ECD detector assembly must be maintained at a high vacuum to eliminate heat loss due to gas conduction and to prevent contamination of the detector crystal. This vacuum is maintained by the continuous operation of an ion pump. Power for this pump normally comes from the AC line, or from the internal backup battery if the instrument is not plugged in. A fully charged battery will support the ion pump for 72 hours, however this battery is used during shipping so the instrument should be connected to an AC power source immediately upon receipt. If ion pump power is lost, the housing vacuum will begin to decrease and within 3 hours it can deteriorate to a level at which the ion pump will not function properly when power is reapplied. Such a condition should be avoided since it can only be corrected by repair or replacement of the ECD assembly.

Liquid nitrogen maintenance

The LN level must be maintained whether or not the system is in use. The LN dewar should be filled upon receipt of the instrument and at regular intervals thereafter. Although it is unusual, the detector crystal can be damaged by frequent temperature cycling experienced when the dewar is allowed to reach room temperature between fillings. In addition, condensation forms inside the dewar as it is approaching room temperature. If this water is not removed before filling the dewar with LN, ice will form inside. The ice can lead to performance problems and corrosion of the dewar interior.

5.4 QuanX Setup

This section describes the procedures required to complete the basic setup in preparation for functional and performance testing.

Conditions

The installation site must meet the requirements detailed in Section 5.2, Site Preparation.

Required equipment

Basic hand tools

Safety precautions

Lifting hazard - The QuanX weighs between 175 lb. (80kg) and 200 lb. (91kg), depending on options installed. If lifting must be done manually, it requires two or more people. The correct place to grasp the enclosure is directly under the frame rails located around the perimeter of the base.

Procedure

1. Unpack the QuanX from its shipping container. Place it on a bench or table top.
1. Verify that both AC line voltage selection switches on the rear panel are set correctly for the local line voltage. If they are not, reset *both* switches and also install the correct value instrument and vacuum pump fuses if required.
1. Plug the instrument power cord into an appropriate outlet. Do not turn on the power switch at this time. Note: For ECD version instruments, the fans will start even when the power switch is off.
1. LN version - Fill the dewar with liquid nitrogen using a funnel and appropriate personal safety gear. Expect large quantities of gas to escape rapidly as the LN contacts the warm dewar. Pour slowly to reduce splashing until the LN begins to flow smoothly.

   ECD version - Open the left top cover and switch the COOLERS switch to the ON position (left). This switch is located on the ECD control board and is shown in Figure 3.5. The COOL ON light should turn on, the EXT COOL OK light should turn off, and the HEAT SINK OK and I.P. CUR. OK lights should remain on. The EXT COOL OK light should turn on within ten minutes.

   For either model, the detector requires approximately two hours to reach operating temperature.
1. Unpack the personal computer (PC) and place it near the QuanX. The computer monitor should not be closer than 1 foot (0.3 meter) from the QuanX if possible. Connect the 9-pin RS-232 serial communication cable to the QuanX rear panel connector and to the PC COM1 port. If the computer has a 25 pin COM1 connector, a DB9M-DB25F adapter will be required.
1. Connect the ADC interface cable to the ADC interface board installed in the PC. If the PC was not supplied by Spectrace Instruments, this board must be installed by following the procedure given below in Section 5.5, Personal Computer Setup. If this is the case, continue with the QuanX setup and connect the ADC interface cable later.

1. Open the sample chamber lid. Turn on the QuanX power switch and verify that the following operations occur. The filter wheel should rotate, reverse direction one or more times quickly, and stop. The sample tray (if installed) should do the same and stop with position 1 toward the front. If the filter and sample tray do not initialize correctly, try turning off the power, unplugging the power cord, and removing and reinstalling the chamber control board (rear-most board) in the card cage.

Note

An alarm will sound when the power switch is turned on if the detector has not yet cooled sufficiently. The alarm may be silenced by pressing the ALARM MUTE button located on the bias supply board in the card cage.

5.5 Personal Computer Setup

This section is applicable only if the computer was not supplied by Spectrace Instruments. If the computer was supplied with the instrument, skip this section and continue with Section 5.6, Performance Testing.

This section describes the procedures required to install the computer. Both hardware assembly and software installation are required.

5.5.1 QUANX Program Installation

This section discusses the process of installing the analysis program, QUANX, onto the computer's fixed disk from the master release diskette. For a new installation the INSTALL program is used. If the program has previously been installed on the computer, the UPDATE program is used. For instruments equipped with special options, such as the R-Theta sample stage, the program name may be different.

Conditions

The computer must be completely assembled and operational. The DOS operating system must be installed on the computer's fixed disk in drive C: in a directory call \DOS.

Required equipment

Spectrace Instruments master release diskettes

Safety precautions

Routine

Procedure - Using INSTALL for a new installation

The master diskette contains an installation program which will automatically create the required sub-directories on the fixed disk and transfer all the required files. A new copy of the files AUTOEXEC.BAT and CONFIG.SYS will be installed in the root directory of drive C:. Previously existing versions of these files, if any, will be renamed with the extension .BAK (to AUTOEXEC.BAK and CONFIG.BAK) and stored in the root directory. Because these files may contain entries unique to the particular configuration of your computer—such as hardware device drivers—it may be necessary to edit the new version and add any required instructions. A word processing program or the DOS EDIT function may be used to view and modify the files.

The new AUTOEXEC.BAT and CONFIG.SYS files contain the default parameters for a typical installation. The CONFIG.SYS file contains a statement which reserves a block of memory for the ADC interface board. If an address other than the default is chosen for this board, the CONFIG.SYS file must be modified. See the sections DOS Operating System Configuration and ADC Interface Board Installation in this chapter for more information.

Note: Pressing ENTER (return) is implied for each of the following commands. Also, the notation C:\> is used to indicate the DOS prompt and is not to be typed when entering DOS commands.

1. Insert the master diskette into drive A: and type

   C:\>a:install

   follow the on-screen instructions as required.

2. Use DOS EDIT to copy any required statements from the CONFIG.BAK and AUTOEXEC.BAK files into the .SYS and .BAT versions, respectively.
2. Reboot the computer by pressing the CTRL ALT DEL keys simultaneously.
2. Run the Spectrace Instruments configuration program TXCONFIG to configure the software for the particular hardware options installed in the QuanX system. Refer to the QuanX operators manual for more information on TXCONFIG. To run the program type

    C:\>txconfig

    and select QuanX from the model list. Normally the only entries which may need modification are the detector type (ECD or LN) and the number of sample tray positions. Press the space bar to step through the available options for each item.

Procedure - Using UPDATE to install a new version

The UPDATE program will copy all the required files from the release diskettes onto the hard disk. It will also copy new versions of the AUTOEXEC.BAT and CONFIG.SYS as INSTALL does. *(This applies to the new install discs that include the file "TSRFont.com".)*

Note: Pressing ENTER (return) is implied for each of the following commands. Also, the notation C:\> is used to indicate the DOS prompt and is not to by typed when entering DOS commands.

1. Insert the master diskette in drive A: and type

    C:\>a:update

1. Follow the on-screen instructions as required.
1. Reboot the computer by pressing the CTRL ALT DEL keys simultaneously.

5.5.2 DOS Operating System Configuration

This section discusses the settings required to establish an environment in which the analysis software will operate properly. This section does not attempt to detail the basic installation of DOS, rather it addresses the particular configuration required to operate the QuanX system. Refer to the DOS documentation for step by step installation instructions.

Conditions

The computer must be completely assembled and operational. DOS 5.0 or higher must be installed on the computer's hard disk drive C: in a directory called \DOS. The computer's hardware configuration must meet the minimum requirements detailed in the specifications portion of Section 3, PRODUCT DESCRIPTION.

Required equipment

None

Safety precautions

Routine

Procedure

There are two files located in the root directory which set the operating parameters of the computer, CONFIG.SYS and AUTOEXEC.BAT. DOS reads these files only during the computer's boot-up sequence.

When the analysis software, QUANX, is installed, a CONFIG.SYS and AUTOEXEC.BAT file are automatically created. It is recommended that the installation of the QUANX program be completed before continuing with this procedure.

Following is an example of each file with a brief description of the function of each line. Note that the type of computer and amount of memory installed may affect the file entries.

Sample CONFIG.SYS file

```
DEVICE = C:\DOS\HIMEM.SYS[1]
DEVICE = C:\DOS\EMM386.EXE NOEMS X=D800-DBFF[2]
DOS = HIGH,UMB[3]
DEVICE = C:\SPECTRAC\VDIDY010.SYS /R[4]
DEVICE = C:\SPECTRAC\VDIPRGRA.SYS /R[5]
DEVICEHIGH = C:\SPECTRAC\VDI.SYS[6]
DEVICEHIGH = C:\DOS\ANSI.SYS[7]
BREAK = ON[8]
FILES = 40[9]
```

Notes:

1. HIMEM.SYS is a memory manager for upper memory.

1. EMM386.EXE provides access to the upper memory area. NOEMS restricts high memory for use as "extended memory" only, not "expanded memory".

   X=D800-DBFF prevents DOS from using the memory block specified. This is required to reserve space for the Spectrace Instruments ADC Interface Board. Note that the address must be entered in a 4 digit format. Simply drop the last digit from the address listed in TXCONFIG. The address block shown, D800 to DBFF, is the default. The actual reserved block will be determined when the ADC interface board is installed. Use a word processing program or the DOS EDIT function to modify the addresses in this file. See the instructions for installing the ADC interface board for more information.

1. Instructs DOS to load itself into high memory.

1. Graphics driver for EGA displays used in the QUANX analysis program. Do not attempt to load this driver high.

1. Graphics driver for the IBM Proprinter™. Do not attempt to load this driver high.

1. VDI controller driver. This driver may be loaded high.

1. Screen and keyboard device driver.

1. System environment setting.

1. System environment setting.

The order that some of the CONFIG.SYS commands are entered in the file is critical. Any additional commands to be entered should be placed at the end of the file.

<u>Sample AUTOEXEC.BAT file</u>

```
PATH = C:\;C:\DOS;C:\SPECTRAC¹
C:\DOS\SMARTDRV²
C:\SPECTRACE\TSRFONT.COM
INIT_VDI³
PROMPT $P$G⁴
XRAYOFF /4⁵
```

Notes:

1. Specifies a search path for DOS to locate files. The path may be increased by adding additional sub directories but must contain at least the sub directories shown.
1. Establishes a disk cache in upper memory. Improves system performance by reducing fixed disk access times.
1. Initializes the VDI controller.
1. Configures the DOS prompt to display the current path. This may be modified as desired.
1. Executes a Spectrace Instruments program which turns off the X-rays. This is included in case the computer was reset during an acquisition.
1. This line should only be included if needed. It corrects a graphics display problem associated with certain brands of video board. The problem appears as garbled function key icons and peak labels.

The preceding examples detail the minimum configuration required to operate the analysis software. DOS offers a number of optional features designed to optimize the speed and flexibility of the computer. Refer to the DOS documentation for details relevant to your particular computer configuration.

5.5.3 ADC Interface Board Installation

Following are instructions for installing the Spectrace ADC interface board for use in PCs with an ISA bus. The purpose of the procedure is to set the board address that will be used for communication between the PC and the ADC interface board. This address may be different for some systems due to the presence of other interface devices in the PC that conflict with the board address preset at the factory.

The ADC interface board uses an upper memory block (memory mapped) address for spectral data transfer and an I/O mapped address for control communication between the PC and the ADC board. This procedure is used to select a memory mapped address, the I/O address is fixed at 330H.

The DOS 5.0 and higher operating systems use the same high memory area as the ADC interface board. Due to this, after an address is selected the CONFIG.SYS file must be modified to prevent DOS from using the memory area chosen for the board. The file may be modified using a word processing program or by using the DOS EDIT function.

To allow the QUANX analysis program to locate the ADC interface board, the address selected must be entered in the TXCONFIG program.

Conditions

The computer must be completely assembled and operational.

In order to perform the final test of the board operation, spectral display, the entire QuanX system must be connected and operational.

Required equipment

Spectrace Instruments part number 5911-0224 (or old version 5911-0181) ADC interface board.

Safety precautions

Routine

Procedure

1. Run TXCONFIG to select the appropriate system options. On the first menu, select the type of system being installed, press ENTER, and select COMPUTER. At the COMPUTER - PRINTER menu, on the MICROCHANNEL OR PC (ISA) BUS line, enter P to choose PC bus. The MEMORY ADDRESS USED will be D8000.

1. Turn off the power to the computer, and install the ADC interface board. Turn on the power to the computer.

   a) If the system boots up and initializes normally, the current address setting will probably work. Go to step 4.

   b) If the screen remains blank or does not function properly, there is probably an address conflict. If during initialization of the system there is an error message related to a hard disk interface or expanded memory, this also indicates an address conflict. Go to step 3.

3. Below is a list of the choices of memory mapped addresses for the ADC interface board. The interface requires a contiguous block of open memory 16K in length. Turn off the power, set SW1 to one of the values listed in Table 1, turn on the power. Return to step 2.

Table 1 ADC Interface board address

ADDRESS BLOCK USED	SWITCH SETTING FOR SW 1	
C0000-C3FFF	OFF 1,2	ON 3,4,5,6,7,8
C4000-C7FFF	OFF 1,2,6	ON 3,4,5,7,8
CC000-CFFFF	OFF 1,2,5,6	ON 3,4,7,8
D0000-D3FFF	OFF 1,2,4	ON 3,5,6,7,8
D4000-D7FFF	OFF 1,2,4,6	ON 3,5,7,8
* D8000-DBFFF	OFF 1,2,4,5	ON 3,6,7,8
DC000-DFFFF	OFF 1,2,4,5,6	ON 3,7,8
E0000-E3FFF	OFF 1,2,3	ON 4,5,6,7,8
E4000-E7FFF	OFF 1,2,3,6	ON 4,5,7,8
E8000-EBFFF	OFF 1,2,3,5	ON 4,6,7,8
EC000-EFFFF	OFF 1,2,3,5,6	ON 4,7,8

Notes:

1) * = Default setting
2) Settings of SW2 (I/O address): OFF 1,2,5,6 ON 3,4,7,8

4. If the switch settings have been changed from the factory settings, the CONFIG.SYS file must be modified. To prevent DOS from using the memory area required for the ADC interface board, the address block chosen must be reserved via a statement similar to "X=D800-DBFF" in the CONFIG.SYS file. Note that the address must be entered in a 4 digit format. Simply drop the last character from the address listed in Table 1. The complete line in the CONFIG.SYS file would appear as:

   DEVICE = C:\DOS\EMM386.EXE NOEMS X=D800-DBFF

   with the address block chosen replacing the default values shown.

   To make the new value active, reboot the computer by pressing CTRL ALT DEL simultaneously.

3. If the switch settings have been changed from the factory settings, turn on the computer and run TXCONFIG. Select the type of system being installed, press ENTER, and select COMPUTER. At the COMPUTER - PRINTER menu, on the MEMORY ADDRESS USED line, enter the address block that corresponds to the switch settings used. The space bar may be used to step through the available options.

3. Start the QUANX program by typing

   C:\>quanx

   and test spectrum acquisition by running the energy calibration routine. If spectrum acquisition does not function properly (no peaks, solid block, random lines or dropouts, etc.), choose a different address and repeat steps 2 - 5.

   Note

   The first time spectrum acquisition is attempted a few basic steps should be taken to ensure that the instrument is capable of producing X-rays and generating a spectrum. Failure to ensure this basic level of performance may cause an unrelated problem to be misinterpreted as an unsuitable address setting. The following steps are recommended:

   - Place the copper calibration disk in the sample chamber (tray position 20 if installed)
   - Before starting the energy calibration function, check the fast discriminator setting on the system status screen. If it is not between 50 and 300, it must be adjusted per procedure.
   - Before starting the energy calibration function, open the left top cover and bypass the interlock switch by pulling up on its actuator. Verify that the PA RESET light on the pulse processor flashes at a rate of less than 5 per second with the X-rays off and at a much higher rate (even on constantly) when the X-rays turn on.

5.5.4 Printer Configuration

This section discusses the printer settings required to insure proper operation with the QUANX program. Because many different printer models are compatible, the information given is of a general nature and no specific models are addressed. Any printer will print text such as procedure menus and analysis results. To print the graphics images, spectrum and calibration curves, a compatible graphics printer is required.

The analysis program requires an IBM Proprinter™ or equivalent. If the printer is not an IBM, set it to emulate one of the following models:

IBM Graphics printer 5152
IBM Proprinter
IBM Proprinter II
IBM Proprinter X24

Set the printer's "Automatic Carriage Return" to ON. The printer manual may refer to this as "Auto CR." Virtually all printers (including IBM) require this change, normally the default will be set to OFF.

5.6 Performance Testing

To ensure that the instrument is operating correctly, the following test and adjustment procedures should be carried out in the order listed. The detector should have been allowed to cool for at least two hours, and the QuanX power switch should have been on for at least 15 minutes.

The procedures listed may be found in Section 7, Test and Adjustment Procedures.

1. Fast discriminator adjustment
1. Interlock test
1. Energy calibration
1. Resolution test
1. Resolution and stability test

DISCARD THIS PAGE

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6. Periodic Maintenance

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6.1 Introduction

The QuanX analyzer is inherently a low maintenance instrument. The maintenance procedures prescribed in this section and in the Operators manual are of a preventative nature. By periodically performing inspections, unscheduled down-time will be reduced.

This section does not include procedures for application related operational maintenance tasks such as standardization of the instrument. Refer to the QuanX Operators manual and/or an applications specialist for information on operational maintenance.

The maintenance requirements are presented by frequency of service.

6.2 Maintenance Procedures

6.2.1 Daily

Action	Comments	Procedure Number
Energy calibration	Failure to calibrate daily may result in inaccurate quantitative results and cause peaks to not line up with KLM markers.	7.3
Run a check-standard	Running a known sample as an unknown is an excellent empirical method of checking instrument performance. The sample should be similar to those normally analyzed; it should also be mechanically and chemically stable.	N/A

6.2.2 Weekly

Action	Comments	Procedure Number
Fill LN dewar (if applicable)	This is an absolute minimum frequency, twice a week is the preferred fill schedule. The dewar should be filled to the *bottom* of the neck, or if filled to the top wait until it boils down to perform quantitative analysis. The increased boiling when LN is in the neck area can degrade resolution. *CAUTION* *The LN level must be maintained whether or not the system is in use. The detector crystal may be damaged by frequent temperature cycling caused by allowing the LN to run out.*	N/A
Check fast discriminator adjustment	The fast discriminator value is located on the system status screen. If the FD is set too low, the minimum energy limit will be too high, causing low energy peaks to be lost. If the FD is set too high, the dead time readings can be inaccurate and will be higher than normal. The FD does not normally require much adjustment. Drastic changes (>100) may indicate some other problem with the system.	7.2

6.2.3 Monthly

Action	Comments	Procedure Number
Run an overnight stability test	The Resolution and Stability test performs repetitive analysis on a sample until it is stopped. Instability due to changes in the X-ray tube output or peak shift will be detected. Save the printout in a maintenance log.	7.12
Print the system status screens	By maintaining a record of the system voltages, trends may be detected. Also, this history information is very helpful for comparison purposes when diagnosing hardware problems. Use the HARD COPY key to print a copy of the SYSTEM STATUS, GENERAL STATUS, and ECD STATUS (if applicable) screens. Allow at least two screen updates before printing. Save the printouts in a maintenance log.	N/A
Check the vacuum pump oil level (optional equipment)	The oil level should be in the middle of the sight glass.	N/A

6.2.4 Semiannually

Action	Comments	Procedure Number
Perform state mandated safety checks	Some states require regular safety testing. If so, an interlock test and a radiation survey are normally required. The results must be maintained in a log book. See Section 2, Safety, for more information.	N/A

6.2.5 Annually

Action	Comments	Procedure Number
Remove dirt from the air pan and X-ray tube body	If the instrument is operating in a dirty environment, the air pan may collect debris. Also the X-ray tube and shroud may be covered with dirt which reduces tube cooling efficiency. If significant quantities of dirt are found, fan filters should be installed.	9.7.1
Test the interlock circuit	To verify proper operation of the interlock circuit.	7.6
Replace the vacuum pump oil (optional equipment)	If the oil appears dark brown or has a “burnt” smell, it should be changed using the same type of oil.	See pump manual

7. Test and Adjustment Procedures

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7.1 Introduction

This section contains procedures for adjusting the operating characteristics of individual hardware modules, and procedures which test the system or its modules on a pass/fail basis. They are used for checkout of the instrument after installation or replacement of a component and for troubleshooting. Other sections of the manual reference the tests in this section.

The procedures assume that the reader need not be instructed on the use of a voltmeter or an oscilloscope to make a voltage measurement or signal waveform measurement, or to get a program on diskette loaded and running on a personal computer.

Many of the test procedures are performed while running the QUANX program. Directions to run this program and to make use of the soft keys available under its various menus are found in the Spectrace QuanX Operators manual. In this section, the QUANX soft keys are always identified by name of the function they invoke under a given menu rather than by the numbers, F1 - F10, by which they are labeled on the keyboard.

Many procedures give two values for the acquisition parameters. The first is for an instrument equipped with a liquid nitrogen cooled detector. This is followed by a value in parentheses which is for an instrument equipped with an electrically cooled detector. If only one value is given then it is applicable to both configurations.

Preset parameters for several tests are stored in files on a diagnostic diskette (P/N 8150-0129) supplied with this manual. Use of the disk is helpful but not required. All test parameters and setup information are detailed in each test procedure. The disk contents may be installed using the INSTALL program on the disk and as described in Section 8, Diagnostic Software. The files will be located in two directories called C:\SPECTRAC\QTESTLN and C:\SPECTRAC\QTESTECD. The test parameters are slightly different for LN and ECD systems. Start the QUANX program from the appropriate directory or use the CDIR function within QUANX.

7.2 Fast Discriminator Adjustment

Scope and purpose

To adjust the fast discriminator threshold of the pulse processor so that the processor rejects background noise but does not cut off the low energy portion of the spectrum.

This threshold should be checked weekly and adjusted whenever the ADC board, the pulse processor board, or the detector has been changed.

Test conditions

Complete, fully functional system.
The power has been on for at least two hours.

Test equipment

Universal adjustment tool (tweeker) or small flat blade screwdriver.

Test procedure

1. Start the QUANX program. Press SETUP and SYS STAT.
1. Read the FAST DISC RATE value. This number changes about once per second, and normally has a range of about 50 counts (150 ± 25).
1. If the average rate is not between 125-175, adjust the FAST DISC pot on the pulse processor board (clockwise to decrease the count rate, counterclockwise to increase) to obtain an average value of approximately 150. Note that the X-rays should have been off for at least 10 minutes and the power should have been on for at least two hours. Figure 7-1 shows the locations of the adjustment pot.

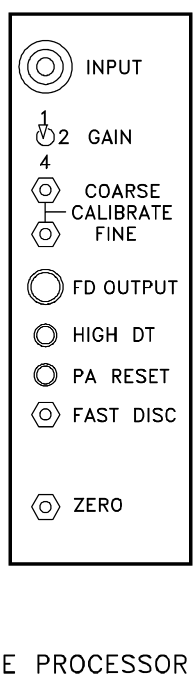


Figure 7-1 Pulse processor adjustment pots and indicator lights

7.3 Energy Calibration

Scope and purpose

To adjust the pulse processor gain so that detected X-rays appear at the correct energy. This is an automated process which should be executed daily.

Test conditions

For the computer to locate the peaks and automatically adjust the system gain, the hardware gain adjustment must be close to correct. This adjustment is explained in Procedure 7.9, Initial Energy Calibration.

The calibration should be performed on the count rate range used for unknowns analysis because there may be a small energy calibration deviation between the three count rate ranges.

Test equipment

Spectrace OFHC copper calibration standard

Procedure

Note

Steps 2-6 are to verify or set the correct acquisition parameters. This setup will be saved and remain as the default configuration until it is changed again. Therefore those steps are normally required only once and need not be executed daily

.

1. Start the QUANX program. The PROCEDURE menu will be displayed.
1. Press SETUP, SYS STAT and ECAL CONFG. Verify the acquisition parameters:

Tube voltage	20 kV
Tube current	0.08 mA (0.16 ECD)
Filter	Pd medium
Livetime	600 sec
Preset count	0K
Max energy	20 keV
Atmosphere	Air
Warmup	20 sec

1. Press SYS STAT and COUNT RATE and set the desired range (Medium for most applications).
1. Press EXIT twice. Enter 8041 (for copper Kα) when prompted for the energy of the line.
1. Press EXIT two times to return to the PROCEDURE menu.
1. Press ENRGY CALIB to run the calibration procedure.
1. The dead time should be approximately 50%. If not, press ACQU MENU & ACQU PARM and adjust the tube current.
1. The procedure displays the current value of the gain DAC and the difference (error) between the actual calibration and the ideal. If the error is greater than 20, terminate this procedure and run the “Initial Energy Calibration” procedure. Otherwise, the system will reset the gain DAC and restart the acquisition automatically. This process will continue until the error value is very low (<1). When this occurs, the procedure will automatically terminate and

save the new DAC value. This value is stored and will be reused until this procedure is executed again (even if the computer is turned off). It normally takes 5 to 15 minutes to complete the energy calibration.

1. If this procedure is terminated prematurely (by pressing EXIT), it asks whether the latest gain DAC value should be saved. If the error is acceptably low (<3 for most applications) respond with “Y.” If the error is too high, respond with “N” to retain the old DAC value. The energy calibration routine must then be restarted if a lower error is desired.

7.4 Power Supply Test and Adjustment

This procedure is presented in two parts. The first part covers the basic system power supplies and applies to all instruments. The second part addresses only the ECD cooler power supply and applies only to instruments equipped with an ECD.

7.4.1 System Power Supplies

Scope and purpose

To measure the power supply voltages and make any required adjustments.

Test equipment

Digital voltmeter (DMM)

Test conditions

None

Procedure

1. Remove the motherboard access panel from the back panel of the instrument.
1. Plug in the power cord and turn the unit on. Use the DMM to measure the voltages on the motherboard connector J3 as shown in Figure 7-2.

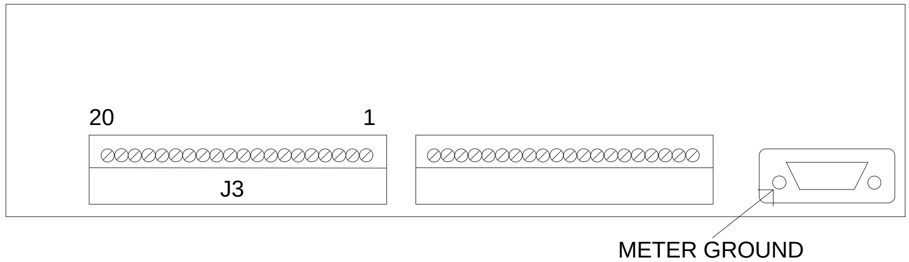


Figure 7-2 Motherboard rear view

J3-	VOLTAGE (V)	POWER SUPPLY
1 2	+5.15 to +5.25	PS1
3 4	0 (gnd)	
5 6	+11.5 to +12.5	PS1 (not adjustable)
7 8	0 (gnd)	
9	-11.5 to -12.5	PS1 (not adjustable)
10	+23.8 to +24.2	PS2B
11	0 (gnd)	
12	+11.9 to +12.1	PS3
13	-11.9 to -12.1	
14	0 (gnd)	
15	+23.8 to +24.2	PS4
16	-23.8 to -24.2	
17	0 (gnd)	
18-20	no connection	

3. Remove the enclosure cover.

3. Measure the voltage on the 24 volt switching power supply PS2. On dual output versions (black body), measure output "A" (threaded studs). On single output versions (silver body) measure any orange wire on the output terminal block. The location of PS2 is shown in Figure 7-3. The voltage should be +25.25 to +25.35. The adjustment points for the dual output version of PS2 are shown in Figure 7-4. The single output version has a single adjustment pot above the output terminal block.

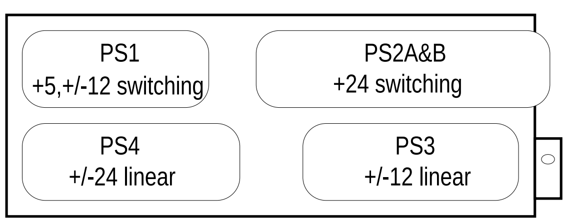


Figure 7-3 Power supply tray, top view

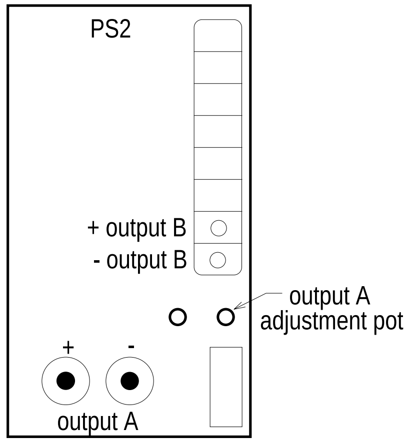


Figure 7-4 PS2 Adjustment points, dual output version shown (black body)

5. If adjustment of any other supply is required, remove the screw securing the power supply tray and slide the tray forward; it may not be removed but will travel forward enough to access the adjustments. The linear power supplies (PS3 & PS4) have the adjustment pots labeled. The smaller switching supply, PS1, has a single adjustment pot below its output connector. This pot adjusts the +5V output, the ±12V outputs are slaved to this output and will respond also. The +5V setting is most critical.
6. To measure the voltages directly on the power supply outputs rather than the at the motherboard connector, refer to Table 7-1.

Table 7-1 Power supply voltages

SUPPLY	VOLT METER POSITIVE	VOLT METER NEGATIVE	VOLTAGE
PS1	TB2-10	TB2-8	+5.20V ± 0.05V
	TB2-4	TB2-3	+12.0V ± 0.5V
	TB2-1	TB2-2	-12.0V ± 0.5V
PS2	+ output B	- output B	+24.0V ± 0.2V
PS3	+ out	com	+12.0V ± 0.1V
	- out	com	-12.0V ± 0.1V
PS4	+ out	com	+24.0V ± 0.2V
	- out	com	-24.0V ± 0.2V

7.4.2 ECD Cooler Power Supply

Scope and purpose

To adjust and test the 8100-7415 DC power supply used for the ECD internal and external coolers in the QuanX.

Test equipment

DVM
Clip leads
1 Ohm, 1%, 50 watt resistor (mounted on a heat sink)
Adjustment screwdriver

Special precautions

In the following procedure you will use a high power resistor to simulate a load. Take care that the resistor does not over-heat during the adjustment procedure. Complete the adjustments quickly after applying power because the resistor value changes slightly as it heats up.

Procedure

The internal cooler supply is a current supply and the external cooler supply is a voltage supply. The location of these outputs are shown in below.

INTERNAL COOLER CURRENT SUPPLY	TRANSFORMER	EXTERNAL COOLER VOLTAGE SUPPLY

ECD Power supply, top view

1. Turn off the instrument power. Disconnect the instrument power cord.
1. Disconnect the ECD control board J3 connector.
1. Connect voltage source (+S) sense terminal to the (+) output terminal with a clip lead.
1. Connect the 1 Ω resistor to the current supply output.
1. Plug in the instrument power cord. The ECD power supply will be on even when the instrument power switch is off.
1. Connect the DVM across the 1 Ω resistor and adjust the current supply's "I ADJ" pot for 3.80 volts across the resistor.
1. Connect the DVM to the voltage supply output. Adjust the "VOLT ADJ" pot for 5.6 volts.
1. Disconnect the 1 Ω resistor from the current supply and measure the output voltage without a load. The voltage should be between 9.5 and 10.5 volts.
1. Unplug the power cord. Disconnect the sense terminal clip lead. Reconnect the ECD board J3 connector. Connect the power cord.

7.5 Latch Adjustment

Scope and purpose

To adjust the lid latch and interlock switches. This is required for proper operation and is also a critical safety related procedure.

Test equipment

Long nose pliers

Test conditions

The main enclosure cover should be removed.

Procedure

1. Loosen the screws holding the chamber lid interlock switch (large black switch) bracket to the baseplate. Adjust the switch body position so that the actuator key enters and exits the switch smoothly as the lid is opened and closed. Tighten the bracket to baseplate screws.

1. Loosen the screws which hold the chamber interlock switch to its bracket. Close the chamber lid. Push the interlock switch body up until it hits the actuator key plastic trim plate. Lower the switch body about 0.1 inch and tighten the screws.

1. Loosen the screws which hold the latch assembly to the baseplate. Close the chamber lid. Energize the latch solenoid using the ECHOA program (CTO↵ CX↵) or a 24 volt power supply. Rotate the latch assembly to achieve the maximum overlap of the solenoid plunger and the chamber lid tongue while not allowing the collar mounted on the solenoid plunger to hit the chamber lid tongue. See Figure 7-2(a) below. Tighten the screws and de-energize the solenoid (CTF↵ CX↵).

1. Adjust the lock sense switch by bending its lever with pliers. This switch must open only when the lid is *actually* locked. Use a tool to push the solenoid plunger back and forth. Adjust the switch trip point (click sound) to be after the solenoid plunger has overlapped the tongue, but before the end of the plunger travel (to insure some switch over-travel). See Figure 7-5(b) below.

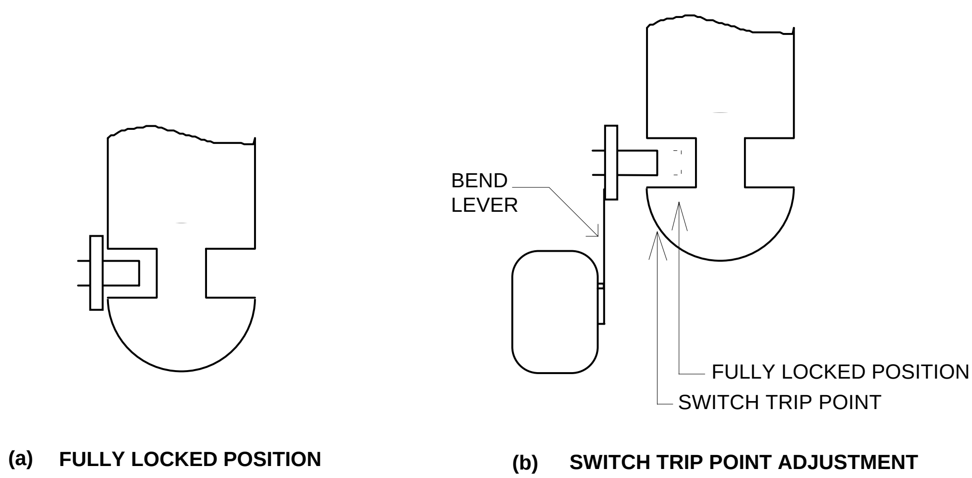


Figure 7-5 Lid latch adjustment

5. The switch which is actuated by the lid tongue (see Figure 7-6) must be adjusted to close *before* the large black chamber interlock switch closes. Turn on the system power, make sure all interlocks are closed so that when the chamber lid is closed, the INTERLOCK DS2 LED on the x-ray control board lights. Bend the switch lever so that as the lid is closed, this switch closes (click sound) well before the LED lights. Close the lid completely and feel the switch lever, it must have a tiny bit of free-play. If it doesn't, it will push the chamber lid up and prevent it from sealing for vacuum properly. The correct adjustment of this switch is a compromise between the two constraints.

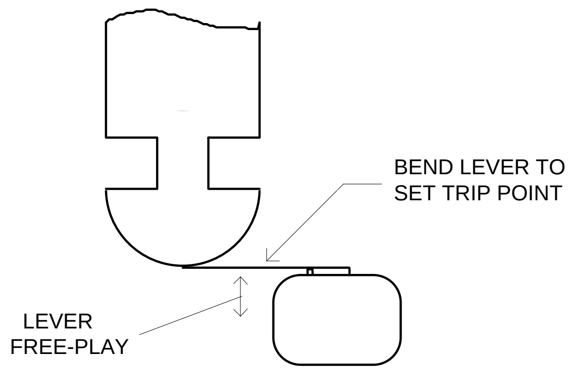


Figure 7-6 "LID CLOSED" sense switch adjustment

7.6 Interlock Test

Scope and purpose

To test the operation of the interlock circuit. This includes not only the operation of the switches but also that of the chamber board and the lid latch. This is a safety related procedure.

Test equipment

None

Test conditions

Procedure 7.5, Latch Adjustment, must have been completed if the latch assembly or primary lid interlock switch were replaced.

Procedure

1. Remove the main enclosure cover.
1. Turn on the system power. Close the chamber lid.
1. The INTERLOCK DS2 LED on the X-ray power supply control board should be off. Press in on the actuator of the front cover interlock switch, the DS2 LED should light.
1. Bypass the front cover interlock switch by pulling out on its actuator shaft. DS2 should be on, open the left top cover, DS2 should turn off.
1. Bypass the left top cover interlock switch by pulling up on its actuator shaft. DS2 should be on, open the chamber lid, DS2 should turn off.
1. Verify that the LID CLOSED LED on the chamber board is on when the chamber lid is closed, and turns off when the lid is opened.
1. Close the chamber lid, start the QUANX program and start an acquisition. Break the front cover interlock by pushing in and releasing its actuator rod. The X-rays should turn off and the computer should be displaying an "open interlock" message. Bypass the interlock switch again, the X-rays should not turn back on.
1. Restart the acquisition and set the tube voltage to 4 kV. Close the lid lock sensing switch (see Figure 7-5b) by pushing on its lever. The XRAY ON DS1 LED on the X-ray power supply control board should turn off (the X-ray warning sign will stay on though). Release the switch lever, DS1 should turn back on. Stop the acquisition.
1. Open the chamber lid very slightly, at a point where DS2 is on but the lid latch will not lock properly. Start an acquisition. The X-rays should not turn on and the computer should display a "chamber failed to lock" message. Close the lid.
1. Unplug the X-ray warning light DB9 connector from the rear panel. Start an acquisition, the X-rays should not turn on (LED DS1 should stay off) and the computer should display a "X-ray warning light failure" message. Reconnect the connector.

7.7 X-ray Power Supply Control Board Adjustment

Scope and purpose

To complete the required board adjustments and check portions of it for proper operation. This procedure may be used to verify the board adjustments, or to check a new board after replacement.

Test equipment

Digital voltmeter (DMM)
100 MHz oscilloscope

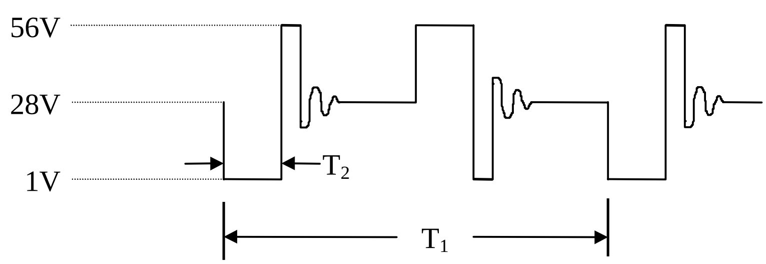
Test conditions

Fully functional X-ray tube and power supply should be connected. The tube must be mounted in the shielded sample chamber.

The main enclosure cover should be removed.

Procedure

1. Check that the 30/50 kV switch is set to the 50 kV position.
1. Turn on the system power. Use a DMM to measure the voltage at TP6 (TP2 is gnd), it should be +15 ± 0.75V.
1. Observe the waveform on TP4 using an oscilloscope. It should look like Figure 7-7.



$40\ \mu S \leq T_1 \leq 50\ \mu S$ and $2\ \mu S \leq T_2 \leq 10\ \mu S$

Figure 7-7 TP4 Waveform

4. Measure the voltage at TP1, adjust R2 for 2.210V.
4. Measure the voltage at TP3, adjust R1 for 2.210V.
4. Check that the hinged radiation shield located at the front of the instrument is in its lowered position.
4. Bypass interlocks as required and turn on the X-rays using the QUANX (in SERVICE MODE) or ECHOA program. Set the tube voltage to 25 kV and current to 0.02 mA. (ECHOA commands CCH25↵ CCI01↵ CTO↵ CX↵ CPO↵ CX↵.)
4. Measure the voltage at TP7, adjust to 5.00V using R33.

4. Set the tube voltage to 4 kV and current to 1.98 mA (CCH04↵ CCI99↵ CX↵ note board doubles ECHOA current values). Measure the voltage at U11 pin 2, it should be 1.72 ± 0.06V. Turn off the X-rays.

7.8 Radiation Survey

Scope and purpose

To measure the radiation leakage outside the instrument at full power, worst case conditions. This is a safety related procedure.

This procedure is written for a particular model of survey meter. If your meter is a different model, disregard the particular references and follow your meter manufacture’s operating instructions.

Test equipment

Dosimeter ring or badge
Survey meter, Victoreen model 493 with model 489-35 probe
Delrin scatter block sample
1”x1” lead sheet
Radiation Survey Recording Form No. 226

Test conditions

Procedure 7.7, X-ray Power Supply Control Board Adjustment, must have been performed if there is any reason to believe that the board may not be functioning correctly.

An X-ray beam collimator must not be installed in the filter wheel holder.

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Safety precautions

Radiation hazard. Test personnel must wear a dosimeter during the test.

Procedure

1. Fill out the survey form.

1. Verify that the survey meter has been calibrated within the last year. Use the test source supplied with the meter to verify that it is working correctly.

1. Remove the sample tray from the chamber, there will be no sample for the first part of this test.

1. All the QuanX enclosure covers should be in place.

1. Select RADIATION SURVEY from the procedure menu or set up an acquisition with the following conditions:

Tube voltage	50 kV
Tube current	1.00 mA
Filter	No filter
Livetime	0 sec
Preset count	0
Max energy	20 keV
Atmosphere	Air
Warmup	0 sec

1. Press RUN. Once the acquisition begins, press ACQU MENU, SYS STAT, GEN STAT. Wait at least 20 seconds to be sure all the voltages have been updated at least once. Check that the "X-RAY H.V. MONITOR" is at approximately 50 kV and that the "X-RAY TUBE ANODE CURRENT" is at approximately 1.00 mA. If they are not, the problem must be corrected before continuing with this test.
1. Turn the knob of the survey meter to BAT. Verify that the meter reads in the green zone. If not, replace the battery.
1. Turn the knob to the x1 position and carefully remove the end cap.
1. **Very, very slowly** move the probe around the instrument at a distance of 2 inches (5cm) from the surface. The probe must be held parallel to the direction from where X-rays would be leaving the system.

   Check all surfaces of the instrument. Pay special attention to the following areas:

   Gap between the chamber lid and baseplate, front and right side.
   All frontal surfaces on the chamber end of the instrument.
   Top of the chamber lid.
   Gap around chamber lid while pulling up on the chamber lid.
1. If a meter deflection above 0.2 mR/h is observed, hold the probe in that location to verify the measurement. Vary the probe angle slowly to find the maximum reading. Only stable readings are valid, it is normal for the meter to jump to about 0.15 mR/h occasionally due to background radiation.
1. To correct for the model 489-35 probe sensitivity at a tube voltage of 50 kV, divide the meter reading by 20. For example:

   x1 scale, meter reading 0.4 mR/h: 0.4 x 1 ÷ 20 = 0.02 mR/h
   x10 scale, meter reading 0.4 mR/h: 0.4 x 10 ÷ 20 = 0.2 mR/h
1. **Verify that the corrected reading is 0.25 mR/h or less (corresponds to an uncorrected reading of 5 mR/h).**
1. Turn off the X-rays. Place a lead sheet over the detector window to protect it from excessive X-ray flux. Do not block any part of the primary X-ray beam with the lead. Install the sample tray in the chamber and put the scatter block in place over the X-ray beam.
1. Repeat the same tests for the scatter block condition. Record the higher of the two readings (no sample versus the scatter block).

7.9 Initial Energy Calibration

Scope and purpose

To set the hardware gain and zero adjustments close to the correct setting so that the automatic energy calibration routine can locate the peaks. This procedure is required when the pulse processor board is replaced.

Test conditions

Complete, fully functional system.
System warmed up for at least an hour.
Fast discriminator checked and adjusted before starting this calibration.

Test equipment

Universal adjustment tool (tweeker) or small flat screwdriver
Spectrace OFHC copper calibration standard

Procedure

1. Verify that the pulse processor GAIN switch is set to the “1” position.
1. Start the QUANX program and press SETUP then SYS STAT.
1. Adjust the coarse zero on the pulse processor so that the zero DAC reads ± 10 or less.
1. Press EXIT to return to the MAIN menu, and press EXIT again to go the PROCEDURE menu.
1. Press ENRGY CALIB, the system begins an acquisition. Press ACQU MENU, SYS STAT, COUNT RATE, and set the pulse processor to the Medium range (or the range most often used for analysis). Press EXIT.
1. Type CU and press Enter to display the KLM markers for the K lines of copper.
1. Position the cursor near the K-alpha line at 8.041 keV.
1. Expand the display until the Cu K-alpha peak fills the screen.
1. Select the ACQ MENU and display the secondary acquisition soft keys.
1. Press ZERO GAIN, and thereby reset the gain DAC to zero. If the Cu peak is close to the marker, the system automatically readjusts the gain DAC to bring the peak closer to the marker.
1. If the Cu spectrum is very far out of adjustment, as illustrated in Figure 7-8, then adjust the COARSE and FINE gain pots on the pulse processor until the Cu peaks are lined up with the KLM markers.

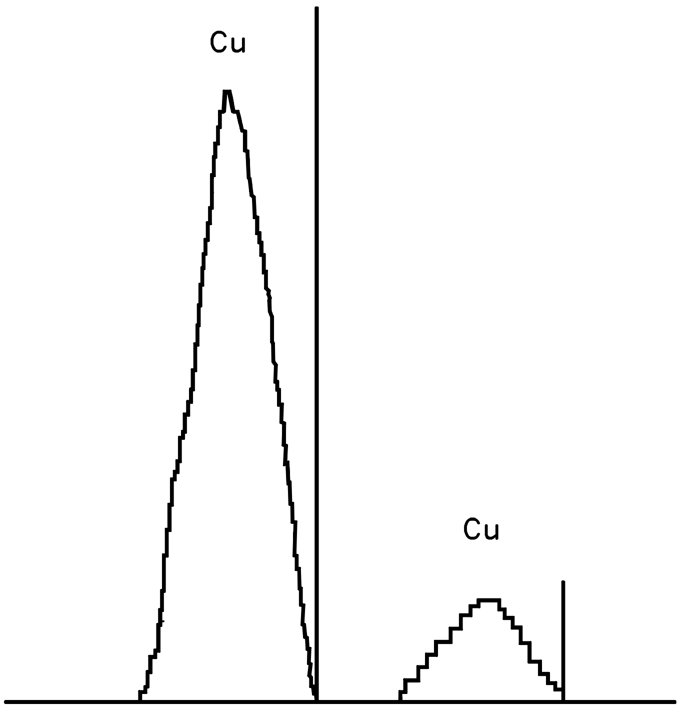


Figure 7-8 System out of calibration

12. Press ZERO GAIN and RESTART to start another acquisition.
1. Repeat this cycle (ZERO GAIN, adjust, RESTART) until the gain DAC is less than ±50eV when the calibration routine stops automatically (or when the ERROR is less than 2).

7.10 Gain vs. Count Rate Range Adjustment

Scope and purpose

To adjust the gain trim pots of the pulse processor to eliminate variation in gain between the low, medium, and high ranges.

Test equipment

Pulse processor extender board (P/N 5610-0159)
20 inch BNC to BNC cable
Small flat screwdriver or adjustment tool
Copper sample

Test conditions

The energy calibration must be close enough to the correct setting to enable the computer to locate the peaks while running ENRGY CALIB. If it is not, perform Procedure 7.9, Initial Energy Calibration, first.

Procedure

1. Put the pulse processor board on an extender board. Use a long BNC cable to connect the input signal. Verify that the pulse processor GAIN switch is set to the “1” position.
1. Start the QUANX program. Press SETUP and SYS STAT.
1. Verify that the ZERO DAC value is less than 300. If it is not, adjust the ZERO pot on the pulse processor. Verify that the FAST DISCRIMINATOR is between 100 and 200. If it is not, adjust the FAST DISC pot on the pulse processor (power must have been on at least 15 minutes).

Calibration of high count rate range

4. Place a copper sample in tray position 20. Press ENRGY CALIB from the procedure menu to start an energy calibration acquisition.
1. Press ACQU MENU, SYS STAT, COUNT RATE and set the pulse processor to the High range. Press EXIT.
1. Make sure that the dead time is approximately 50%. If necessary, press ACQU PARM and adjust the tube current.

Note
If the acquisition parameters must be changed to achieve 50% dead time, wait 20 seconds after making the changes before EXITing in order to allow the zero stabilizer to reach equilibrium.

1. Observe the ERR= number at the bottom left of your screen. This indicates how far off the peak is from where it should be. The GAIN DAC= shows the amount of correction that the system has calculated is necessary to bring the peak into correct gain adjustment.
1. Type CU and press ENTER to display the KLM markers for copper.
1. Press ZERO GAIN to reset the gain DAC to zero. Now observe the peak and marker locations. If the center of the peak is near the K-alpha marker, turn the FINE adjust pot on the pulse processor to line up the peak and marker as close as possible. If the peak is not close to the marker, then start with the COARSE gain adjust pot to bring the peak close to the marker, then use the FINE pot. To move the peak up in energy (a negative error reading)

turn the pot clockwise. To move the peak down in energy (a positive error reading) turn the pot counter clockwise.

1. Adjust the peak so that the error is less than 10 with the gain DAC at zero.

Note

When adjusting to correct the error, press the ZERO GAIN key as necessary so that gain DAC stays at 0.

1. When the peak is as close to the marker as possible by visual inspection, use the software to help evaluate the gain error. Adjust the FINE GAIN pot so that the error is less than + 10 with the gain DAC set (forced) at zero.

Note

If the pot is over-adjusted in one direction, there will be some backlash when adjusted in the reverse direction. It is best to continue turning past this point in the same direction before turning back in the opposite direction.

1. Repeat the steps until the error is less than + 10 when the gain DAC is forced to zero and the system automatically halts calibration. The program halts energy calibration automatically when the error is very small (less than + 1).

Note

If the system halts acquisition before the gain pot is adjusted, restart the energy calibration.

Calibration of medium count rate range

13. Restart the energy calibration acquisition by pressing ENRGY CALIB.

1. Press ACQU MENU, SYS STAT, COUNT RATE and type M to set the pulse processor to the medium range. Press EXIT.

1. Make sure that the dead time is approximately 50%. If necessary, press ACQU PARM and adjust the tube current.

1. Follow steps 7 - 12 as for "calibration of high count rate range" except use R102 (instead of the FINE pot), located just behind the PA RESET light on the front of the pulse processor PCB. This pot may be accessed through the lower hole in the metal cover attached to the left side of the board.

Note

R102 is much more sensitive than the FINE adjustment pot, and has worse backlash.

Calibration of low count rate range

17. Restart the energy calibration acquisition by pressing ENRGY CALIB.

1. Press ACQU MENU, SYS STAT, COUNT RATE and type L to set the pulse processor to the low range. Press EXIT.

1. Make sure that the dead time is approximately 50%. If necessary, press ACQU PARM and adjust the tube current.

1. Follow steps 7 - 12 as for "calibration of high count rate range" except use R101 (instead of the FINE pot), located just behind the PA RESET light on the front of the pulse processor PCB. This pot may be accessed through the upper hole in the metal cover attached to the left side of the board.

Note
R101 is much more sensitive than the FINE adjustment pot, and has worse backlash.

Note
After the low range is calibrated, recheck the high range. If the high range needs to be readjusted, then recheck and readjust the medium and low ranges again as well.

7.11 Resolution

Scope and purpose

To verify the operation of the detector and related circuitry. Either of two samples may be used, manganese or copper. Manganese is the industry standard (5.89keV) for resolution specification. Copper is convenient because it is readily available.

Test equipment

MnO_2 or Cu sample

Test conditions

The system must be energy calibrated, otherwise the resolution results are meaningless.

Procedure

1. Place the sample in sample tray position 20.
12. Start the QUANX program. Press SETUP, then SYS STAT on the main menu, and TEST PROCS on the PHA status page. Select the RESOLUTION - MANGANESE/COPPER test from the menu.
12. Press SETUP to verify:

Tube voltage	18 kV
Tube current	0.04 mA (0.08 ECD)
Filter	Pd medium
Livetime	45 sec
Preset count	0
Max energy	10 keV
Atmosphere	Air
Warmup	5 sec

12. Press SYS STAT, COUNT RATE, and select Low (or desired range) count rate range. Press EXIT. Note: normally only the low range values are of interest.
12. Press EXIT and answer the prompts as follows:

Number of measurements	15
Resolution standard	Mn or Cu as appropriate

12. Press RUN to start the test. Press ACQU MENU & SYS STAT. The FAST DISC RATE should be between 1000 and 1500 cps. If it is not, press EXIT and ACQU PARM and adjust the tube current (DT will be about 22% on low). The system performs the selected number of acquisitions. After each one it prints the following:

    Full width at half-max (FWHM)
    Running average of FWHM
    Peak-to-background ratio at 1 keV
    Peak-to-background ratio at 5 keV
    Averages for the two ratios
    Value of peak centroid

12. **Verify that the final average resolution values are equal to or less than**

	LN			ECD		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Mn:	**155 eV**	**175 eV**	**250 eV**	**175 eV**	**195 eV**	**270 eV**
Cu:	**175 eV**	**195 eV**	**n.s.**	**195 eV**	**215 eV**	**n.s.**

n.s. = not specified

and that the low range manganese peak-to-background final average values are equal to or greater than

	LN		ECD	
	1 KeV	**5 KeV**	**1 KeV**	**5 KeV**
Mn:	**1200**	**550**	**1200**	**400**

copper peak-to-background values are not specified.

Note

The peak-to-background ratio is indicative of the detector alone. The resolution (FWHM) is indicative of the detector and its electronics.

7.12 Stability

Scope and purpose

To verify that the X-ray generation and detection subsystems are functioning correctly. Also to differentiate between problems arising in the two systems.

Test equipment

Copper sample

Test conditions

Complete, fully functional system

Procedure

1. Place a copper sample in tray position 20.
1. Press SETUP, then SYS STAT on the main menu, and TEST PROCS on the PHA status page. Select the RESOLUTION AND STABILITY test from the menu.
1. Press SETUP and enter the following conditions:

Tube voltage	35 kV
Tube current	0.20 mA (0.40 ECD)
Filter	Cu thin
Livetime	300 sec
Preset count	0
Max energy	20 keV
Atmosphere	Air
Warmup	600 sec

Or the test may be run at the conditions normally used for unknowns analysis.

1. Press SYS STAT, COUNT RATE, and select Medium count rate range (or the range used for unknowns analysis). Press EXIT twice. Enter 8041 for the energy of the line.
1. Highlight RESOLUTION AND STABILITY and press RUN. The dead time should be approximately 50%. If not, press ACQU MENU & ACQU PARM and adjust the tube current, press EXIT. Allow the test to run for a minimum of 8 hours.
1. The test results report the total system error (instability). This error is a combination of the instrument error and counting statistics. To evaluate the instrument error alone, use the following formula.

$$\text{Instrument error} = \sqrt{(RSD)^2 - \frac{10{,}000}{N}} \quad (\%)$$

where N = number of total or peak counts from the printout.
RSD = total or peak deviation percentage (e.g.: total = 0.12%, use 0.12 for RSD).

1. **Verify that the instrument error is 0.20 % or less for TOTAL counts and 0.23 % or less for PEAK counts.**

1. The other test values should be as follows

Parameter	Value	Deviation during test
FWHM (resolution)	215eV (typical)	±5eV max
Peak Centroid	8041 (typical)	±3eV max

Interpreting the test results

If the TOTAL and PEAK stability is within specification, no further interpretation is required.

Instrument stability (precision) may be divided into two components: X-ray source stability and X-ray detection stability. A problem in either area will result in poor analysis precision. This test is designed to differentiate between the two.

In general, X-ray source instability will affect the entire spectrum equally. For example, if the X-ray tube output drops by 1%, all areas of the spectrum will drop approximately 1%. This includes the area under the copper peak as well as the background in the rest of the spectrum. The entire spectrum is represented by the TOTAL value.

Conversely, a problem in the X-ray detection system will affect the copper peak counts to a much greater degree than the rest of the spectrum. This can best be explained by example. The two most common X-ray detection problems which cause poor precision are peak shift and unstable resolution (peak width). These conditions are shown in Figure 7-9. In the case of peak shift, less copper counts fall within the region of interest (ROI) boundaries therefore the reported PEAK counts decrease. In the poor resolution case, the peak width increases and since the total number of copper X-rays hasn't changed (peak area is the same), the peak is shorter and therefore less copper counts fall within the ROI. In both cases the PEAK counts drop while the TOTAL counts remain constant.

In summary, the interpretation of the test results rely on the following logic: TOTAL deviation affects the PEAK, but PEAK deviation does not affect the TOTAL. If the TOTAL stability is poor, items such as the X-ray tube, X-ray high voltage power supply, or the X-ray control board are suspect. If the PEAK stability is poor (and the TOTAL is good), look at the peak centroid and FWHM (resolution) columns to isolate the source. Peak instability is most often associated with detector problems, noise pickup, or a faulty pulse processor board.

Refer to the Troubleshooting section of this manual to diagnose the source of poor stability.

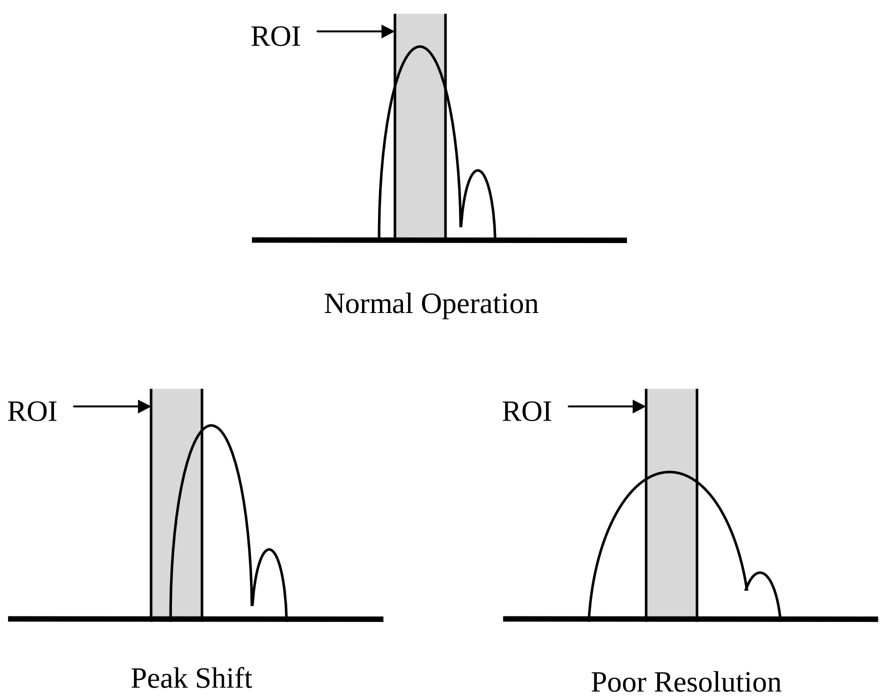


Figure 7-9 Sources of poor PEAK stability

7.13 Repeatability

Scope and purpose

To check that the output of the X-ray tube returns to the same level, for a given kV and mA setting, when the system is turned off and on or momentarily set to different values.

Test equipment

Copper sample

Test conditions

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

1. Remove the sample tray and install the single sample holder.
1. Place a copper sample in position.
1. Select the REPEATABILITY TEST from the procedure menu and press SETUP or set the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	20 kV	Method	:	Linear
Tube current	:	0.06 mA (0.12 ECD)	Mode	:	Run unknowns
Filter used	:	Pd medium	Std. file	:	200
Livetime	:	60 sec			
Preset count	:	0 k			
Max energy	:	10 keV			
Atmosphere	:	Air			
Warmup	:	10 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	200	Spectrum		Yes
Elements of int	:	Cu	Intensities	:	Yes
			File number	:	200
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING	
1.	CU - GROSS ROI <7400 - 9400 EV>

Standards file setup

STANDARDS FILE :		ELEMENTS OF INTEREST
REPEATABILITY FILE NO. :200		CU REL
1	IN	100
2	IN	100
•		• (entries 1 to 15 are identical)
•		•
•		•
15	IN	100
ZERO REF	IN	0

Count rate range setup

AMP COUNT RATE: MEDIUM

4. Highlight ACQUISITION PARAMETERS and press RUN to start the acquisition. Answer the prompts as follows:

No. unknowns	10
All others	Press ENTER

1. The dead time should be approximately 50%. If not, press ACQU MENU & ACQU PARM and adjust the tube current.
1. While sample 6 is being acquired, press ACQU MENU & ACQU PARM. Change the tube voltage to twice the present value, and change the tube current to half of its present value. After 15 seconds, change the voltage and current back to their original values. Wait 20 seconds before pressing EXIT to complete the acquisition of sample 6.
1. After the 10 spectra have been stored, the system turns off the X-rays. Highlight SAVE ON DISK and press SETUP. Change the file number to 210, press ENTER and EXIT.
1. Wait until the X-rays have been off for 2 minutes.
1. Highlight ACQUISITION PARAMETERS again and press RUN. Answer the prompts as follows:

No. samples	5
All others`	Press ENTER

1. After the 5 spectra have been stored, the system turns off the X-rays. Highlight SAVE ON DISK and press SETUP. Change the file number to 200, press ENTER and EXIT.
1. Highlight SPECTRUM PROCESSING and press RUN. Enter 15 for the number of samples to process.
1. Highlight ANALYSIS TECHNIQUE and press SETUP. Change the mode to Standardize. Set print statistics to Yes. EXIT back so that ANALYSIS TECHNIQUE is highlighted and press RUN.

1. The system will print the deviation for each position and calculate an overall sigma.
1. **Verify that the sigma is 0.25 or less.**

7.14 Sample Tray Height Adjustment

Scope and purpose

To set the height of the sample tray to compensate for variations in the x-ray spot location and alignment. Proper height adjustment maximizes the detected flux and minimizes the sensitivity to tray flatness.

Test equipment

Short tray pads or tray height adjustment fixture
Thin (about 0.015") washers
Brass sample

Test conditions

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

1. Use special short tray pads or a tray height adjustment fixture to position the tray at a low starting point, about 0.25".

1. Place the brass sample in tray position 1.

1. Select the TRAY ACCURACY test from the procedure menu and press SETUP, or set up the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	20 kV	Method	:	Linear
Tube current	:	0.06 mA (0.12 ECD)	Mode	:	Run unknowns
Filter used	:	Pd medium	Std. file	:	300
Livetime	:	100 sec			
Preset count	:	0 k			
Max energy	:	20 keV			
Atmosphere	:	Air			
Warmup	:	5 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	300	Spectrum	:	Yes
Elements of int	:	Brass	Intensities	:	Yes
			File number	:	300
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING	
1.	BRASS - GROSS ROI <7200 - 10080 EV>

Count rate range setup

AMP COUNT RATE: MEDIUM

4. Highlight ACQUISITION PARAMETERS and press RUN. Answer 1 for the number of unknowns to run.
1. The dead time should be approximately 50%. If not, press ACQU MENU & ACQU PAR and adjust the tube current.
1. After the acquisition is complete, highlight SPECTRUM PROCESSING and press RUN. Answer 1 for the number of samples to run.
1. Display the spectrum by pressing DISP SPEC then typing C to select the current spectrum. Write down the value of the ROI gross counts displayed on the upper right corner of the screen.
1. Add one washer under each tray pad and repeat the previous steps (do not change the tube current).
1. Continue adding washers one at a time and noting the gross counts. The count value should start low, achieve a maximum, and start dropping as more washers are added. The correct tray height is the one with the highest gross count. Install the corresponding washers or corrected height tray pads in the chamber.

7.15 Sample Tray Accuracy

Scope and purpose

To verify that the system gives the same results when analyzing the same sample in any position. The test uses a set of identical brass plugs, analyzes one in each tray position, and calculates the deviation in counts between positions.

Test equipment

20 1.25" identical brass plugs (cut from the same bar)

Test conditions

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

1. Load the standard sample tray with 20 identical brass samples (for spinner trays see step 2).

1. For systems equipped with the optional sample spinner, test the spinner as follows.

   Exit out of the QUANX program.
   Type ECHOA Q to start the communication program.
   Type CBO ↵ CX ↵.
   Verify that the spinner motor is turning.
   Check that an empty spinner cup turns smoothly in the tray.
   Place a brass sample in the cup and check that it turns smoothly in the tray.
   Press ESC to exit ECHOA. Restart the QUANX program.

1. If the system only has a 10 position sample spinner tray then load 10 brass samples in the spinner cups. This test must be performed with the samples rotating. If the system has both types of tray (or spare trays), repeat the test for the additional tray(s).

1. Select the TRAY ACCURACY test from the procedure menu and press SETUP, or set up the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	20 kV	Method	:	Linear
Tube current	:	0.06 mA (0.12 ECD)	Mode	:	Run unknowns
Filter used	:	Pd medium	Std. file	:	300
Livetime	:	100 sec			
Preset count	:	0 k			
Max energy	:	20 keV			
Atmosphere	:	Air			
Warmup	:	600 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	300	Spectrum	:	Yes
Elements of int	:	Brass	Intensities	:	Yes
			File number	:	300
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING
1. BRASS - GROSS ROI <7200 - 10080 EV>

Standards file setup

STANDARDS FILE :		ELEMENTS OF INTEREST	
Tray accuracy File no. :200		Brass Inten	
Position 1	IN	100	
Position 2	IN	100	
•		•	(Entries 1 to 20 are identical. Enter only
•		•	1 to 10 for the spinner tray.)
•		•	
Position 20	IN	100	
Zero ref IN		0	

Count rate range setup

AMP COUNT RATE: MEDIUM

5. Highlight ACQUISITION PARAMETERS and press RUN. Answer the prompts as follows:

No. unknowns	20 (10 for the spinner tray)
All others	Press ENTER

4. Highlight SPECTRUM PROCESSING and press RUN. Enter 20 (10 for the spinner tray) for the number of samples.

4. Highlight ANALYSIS TECHNIQUE and press SETUP. Change the mode to Standardize. Set print statistics to Yes. EXIT back so that ANALYSIS TECHNIQUE is highlighted and press RUN.

4. The system prints out the difference and relative error for each tray position and an overall sigma value.

4. **Verify that the sigma value is 0.30 or less and that the relative error for any single position is 0.50 or less.**

4. If the test fails, perform Procedure 7.14, Sample Tray Height Adjustment. The correct height greatly minimizes the sensitivity to tray flatness.

7.16 Livetime

Scope and purpose

To test the pulse processor dead time correction circuit, and thus make sure that analysis results are reproducible regardless of the mix of elements in a sample.

Test equipment

Sample cup with copper foil (approximately 0.150" diameter disk) fixed in place between mylar sheets.

MnO_2 powder

Test conditions

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

Note
The dead time with and without manganese is critical for this test. Steps 1,3,4 & 5 are included to determine the correct tube current for the particular sample used. They may be skipped if the sample has already been characterized.

1. Pour some manganese powder in the sample cup, enough to completely cover the bottom of the cup with a thick layer. Place the sample cup in tray position 1.

1. Select LIVETIME TEST from the procedure menu and press SETUP or set up the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	20 kV	Method	:	No analysis
Tube current	:	0.14 mA (0.28 ECD)	Mode	:	Run unknowns
Filter used	:	Pd medium	Std. file	:	400
Livetime	:	100 sec			
Preset count	:	0 k			
Max energy	:	10 keV			
Atmosphere	:	Air			
Warmup	:	10 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	400	Spectrum	:	Yes
Elements of int	:	Cu	Intensities	:	Yes
			File number	:	400
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

```
SPECTRUM PROCESSING
1.      CU - GROSS ROI  <7400 - 9400 EV>
```

Count rate range setup

AMP COUNT RATE: MEDIUM

3. Highlight ACQUISITION PARAMETERS and press RUN. Enter 1 for the number of unknowns.
3. The dead time should be 48 to 55%. If not, press ACQU MENU & ACQU PARM and adjust the tube current. Press EXIT to stop the acquisition.
3. Pour the manganese out of the sample cup and into an empty container. Return the sample cup to tray position 1.
3. With the tube current set to the value determined in step 4, highlight ACQUISITION PARAMETERS and press RUN. Enter 1 for the number of unknowns. The dead time should be 15 to 20%. If not, the size of the copper foil must be adjusted and the test restarted.
3. Highlight SAVE ON DISK and press SETUP. Change the save on disk number to 401. Press EXIT.
3. Return the manganese to the sample cup. Make sure the Cu foil and/or the cup is not moved when the Mn is poured in, otherwise the test must be started over.
3. Highlight ACQUISITION PARAMETERS and press RUN. Enter 1 for the number of unknowns.
3. Change the save on disk number back to 400.
3. Highlight SPECTRUM PROCESSING and press RUN. Enter 2 for the number of samples to run.
3. Highlight ANALYSIS TECHNIQUE and press RUN. The system will print the Cu gross counts for each run.
3. Calculate the percent deviation of gross counts between the two runs using the formula:

$$\text{Percent deviation} = \frac{run1 - run2}{run1} \times 100$$

3. **Verify that the percent deviation is 3.0 % or less.**

7.17 Pileup

Scope and purpose

To test the pulse processor pile-up rejection circuit. This circuit reduces artifact peaks known as *sum peaks*.

Test equipment

MnO_2 sample

Test conditions

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

1. Place the MnO_2 sample in tray position 1.

1. Select the PILEUP TEST from the procedure menu or set up an acquisition with the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	20 kV	Method	:	Peak ratios
Tube current	:	0.18 mA (0.36 ECD)	Mode	:	Run unknowns
Filter used	:	Pd medium	Std. file	:	500
Livetime	:	500 sec			
Preset count	:	0 k			
Max energy	:	20 keV			
Atmosphere	:	Air			
Warmup	:	10 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	500	Spectrum	:	Yes
Elements of int	:	Mn, R1	Intensities	:	Yes
			File number	:	500
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING	
1.	MN - NET ROI <5320 - 6220 EV>
2	R1 - NET ROI <11460 - 12120 EV>

Count rate range setup

AMP COUNT RATE: MEDIUM

Peak ratio setup

SETUP RATIO	
ELEMENT(S) ANALYZED :	
1. R1	11.
2.	12.
RATIO TO : MN	

3. Return to the procedure menu and RUN the PILEUP TEST, enter 1 for the number of unknowns. The system automatically runs the spectrum processing and analysis technique at the completion of the acquisition.

3. The dead time should be approximately 50%. If not, press ACQU MENU & ACQU PAR and adjust the tube current.

3. The system will automatically calculate the ratio of the sum peak (region R1) to the parent peak (region MN).

3. **Verify that the ratio percent is 0.30 or less.**

7.18 Stray Lines

Scope and purpose

To verify that the intensities of any instrument-sourced contamination in the X-ray spectrum are below specified limits. This is accomplished by analyzing a sample known to contain only very light elements which the instrument cannot detect.

The test is broken into two portions. Test II checks for stray lines in the 4 to 10 keV range. Test III checks for stray lines in the 10 to 25 keV range.

Test equipment

Delrin sample

Test conditions

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

7.18.1 Stray Lines II - 25kV

Procedure

1. Place the plastic scatter block in the chamber. Use the single sample tray ("horseshoe" removed) if the sample is not a standard 1.25" diameter size.
1. Select STRAY LINES II test from the procedure menu or set up an acquisition with the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	25 kV	Method	:	Peak ratios
Tube current	:	0.02 mA (0.04 ECD)	Mode	:	Run unknowns
Filter used	:	Pd medium	Std. file	:	600
Livetime	:	500 sec			
Preset count	:	0 k			
Max energy	:	40 keV			
Atmosphere	:	Air			
Warmup	:	0 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	600	Spectrum	:	Yes
Elements of int	:	Cu,Fe,W,R1,R2	Intensities	:	Yes
			File number	:	600
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

```
SPECTRUM PROCESSING
1.    CU - NET ROI  <7740 - 8320 EV>
2.    FE - NET ROI <6120 - 6660 EV>
3.    W - NET ROI <8100 - 8680 EV>
4.    R1 - GROSS ROI <0 - 30000 EV>
5.    R2 - GROSS ROI <5000 - 5500 EV>
```

Count rate range setup

AMP COUNT RATE: MEDIUM

Peak ratio setup

```
SETUP RATIO
ELEMENT(S) ANALYZED :
1. CU                         11.
2. FE                         12.
3. W                          13.
4. R2                         14.
RATIO TO : R1
```

3. Return to the procedure menu and RUN the STRAY LINES II test, enter 1 for the number of unknowns. The system automatically runs the spectrum processing and analysis technique at the completion of the acquisition.

3. The dead time should be 40% to 50%. If not, press ACQU MENU & ACQU PAR and adjust the tube current.

3. The result is the ratio of each element's intensity to the total spectrum.

3. **Verify that the ratio percent for each element is 0.015 or less. R2 is a measure of the background level; verify that the ratio percent is 0.12 or less, for ECD systems. (This parameter is not specified for LN systems.)**

NOTE

If the result exceeds this value, clean the surface of the test sample with a solvent and repeat the test. Any contamination of the surface may cause high results. Also, check that the detector collimator is installed and properly aligned.

7.18.2 Stray Lines III - 50kV

Procedure

1. Place the plastic scatter block in the chamber. Use the single sample tray ("horseshoe" removed) if the sample is not a standard 1.25" diameter size.

1. Select STRAY LINES III test from the procedure menu or set up an acquisition with the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	50 kV	Method	:	Peak ratios
Tube current	:	0.20 mA (0.40 ECD)	Mode	:	Run unknowns
Filter used	:	Cu thick	Std. file	:	700
Livetime	:	500 sec			
Preset count	:	0 k			
Max energy	:	40 keV			
Atmosphere	:	Air			
Warmup	:	0 sec			
SPECTRUM PROCESSING			**SAVE ON DISK**		
Ref file no.	:	700	Spectrum	:	Yes
Elements of int	:	Ag,Sn,R1,R2	Intensities	:	Yes
			File number	:	700
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING
1. AG - NET ROI <21580 - 22580 EV>
2. SN - NET ROI <24600 - 25700 EV>
3. R1 - GROSS ROI <0 - 40920 EV>
4. R2 - GROSS ROI <15000 - 16000 EV>

Count rate range setup

AMP COUNT RATE: HIGH

Peak ratio setup

SETUP RATIO
ELEMENT(S) ANALYZED :

1. AG	11.
2. SN	12.
3. R2	13.

RATIO TO : R1

3. Return to the procedure menu and RUN the STRAY LINES III test, enter 1 for the number of unknowns. The system automatically runs the spectrum processing and analysis technique at the completion of the acquisition.
3. The dead time should be 40% to 50%. If not, press ACQU MENU & ACQU PAR and adjust the tube current.
3. The result is the ratio of each element's intensity to the total spectrum.

3. **Verify that the ratio percent for each element is 0.05 or less. Verify that the ratio percent for R2 is 0.30 or less, for ECD systems. (This parameter is not specified for LN systems.)**

NOTE

If the result exceeds this value, clean the surface of the test sample with a solvent and repeat the test. Any contamination of the surface may cause high results. Also, check that the detector collimator is installed and properly aligned.

7.19 Minimum Detection Limits

Scope and purpose

To measure the sensitivity of the system when analyzing an oil sample with known concentrations of iron and lead.

Test equipment

Conostan S-12 100 ppm trace elements in oil

Test conditions

Optional - The diagnostic diskette contents has been installed and the QUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

1. Shake the sample cup containing the oil to mix the elements thoroughly. Place the sample cup in position 1.

1. Select the OIL MINIMUM DETECTION LIMITS test from the procedure menu or set up an acquisition with the following conditions:

Overall setup

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	22 kV	Method	:	No analysis
Tube current	:	0.06 mA (0.12 ECD)	Mode	:	Run unknowns
Filter used	:	Pd medium	Std. file	:	800
Livetime	:	300 sec			
Preset count	:	0 k			
Max energy	:	20 keV			
Atmosphere	:	Air			
Warmup	:	0 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	800	Spectrum	:	Yes
Elements of int	:	Fe,Pb	Intensities	:	Yes
			File number	:	800
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING	
1.	FE - NET ROI <6120 - 6660 EV>
2.	PB - NET ROI <10120 - 10860 EV>

Count rate range setup

AMP COUNT RATE: MEDIUM

3. Return to the procedure menu and RUN the OIL MINIMUM DETECTION LIMITS test, enter 1 for the number of unknowns. The dead time should be approximately 50%. If not, press ACQU MENU & ACQU PARM and adjust the tube current.

1. The system automatically runs spectrum processing and prints out peak and background intensities. Calculate the MDL for Fe and Pb using the following formula.

$$\text{MDL} = \frac{3 \times C_{std} \times \sqrt{I_{bkgnd}}}{I_{peak}} \quad \text{(ppm)}$$

where: C_{std} = concentration in the standard (ppm) (100 for Conostan S-12)
I_{peak} = peak intensity
I_{bkgnd} = background intensity

1. **Verify that the MDL values are equal or less than**

LN:	**Fe 3.0 ppm**	**ECD:**	**Fe 7.0 ppm**
	Pb 5.0 ppm		**Pb 5.0 ppm**

7.20 Voltage and Current Steps

Scope and purpose

To verify that the X-ray generator responds correctly to voltage and current commands.

Test equipment

Copper sample

Test conditions

Procedure 7.7, X-ray Power Supply Control Board Adjustment, should have been completed if the board's condition is unknown or suspect.

Procedure

In this test the X-ray tube current and anode voltage are varied and changes in some system parameters are observed. The tube's X-ray output intensity is directly proportional to the current. Therefore, an increase in the tube current will increase both the system count rate and dead time. In this test we will observe the dead time as the current is varied. The tube's output intensity is a nonlinear function of the anode voltage; therefore the programming voltage for the high voltage supply is monitored when the anode voltage is varied.

1. Place the copper sample in tray position 1.
1. Highlight VOLTAGE AND CURRENT STEPS from the procedure menu and press SETUP or set up the following conditions:

Tube voltage	26 kV (30 ECD)
Tube current	0.10 mA
Filter	Pd thick
Livetime	0 sec
Preset count	0
Max energy	20 keV
Atmosphere	Air
Warmup	0 sec

1. Press SYS STAT, COUNT RATE, and select Medium count rate range. Press EXIT.
1. Highlight ACQUISITION PARAMETERS and press RUN. Answer 1 for the number of unknowns to run.
1. Press ACQU MENU, then ACQU PARM to access the acquisition parameters menu. If necessary, adjust the tube *voltage* to get approximately 50 % dead time. Observe and record the dead time. Reduce the current to .08 mA. The dead time should decrease to approximately 43 percent. Continue reducing the current in .02 mA steps and checking the dead time. See the LOW CURRENT TEST column of the table below for typical values. Stop when the current is .02 mA.

NOTE

It is normal for the dead time to fluctuate plus or minus a few percent about the nominal value. Pause at each step long enough to determine an average value.

LOW CURRENT TEST (mA)	HIGH CURRENT TEST (mA)	DEAD TIME (%)
0.10	1.00	50
	0.90	47
0.08	0.80	43
	0.70	39
0.06	0.60	36
	0.50	33
0.04	0.40	29
	0.30	24
0.02	0.20	20

4. Repeat step 3, starting at 20 kV (21 ECD) and 1.00 mA. If necessary, adjust the tube *voltage* for 50 % dead time. Measure the dead time at currents from 1.00 to 0.20 in 0.10 increments. Compare with the typical values in the HIGH CURRENT TEST column of the previous table.

4. Set the following conditions:

Tube voltage	4 kV
Tube current	0.02 mA
Filter	Cu thick

4. Press SYS STAT, then GEN STAT to view the general status page. Wait for the X-RAY H.V. CONTROL to be updated at least once. Check that the control voltage is within the range specified in the following table. Press EXIT twice to return to the acquisition parameters menu. Repeat for the other tube voltages in the table.

TUBE VOLTAGE (kV)	X-RAY H.V. CONTROL (kV)
4	3.90 - 4.10
10	9.70 - 10.30
20	19.40 - 20.60
30	29.10 - 30.90
40	38.80 - 41.20
50	48.50 - 51.50

7. Push EXIT twice to stop the acquisition. Test complete.

7.21 Chamber Vacuum Test

Scope and purpose

To test and adjust the sample chamber vacuum subsystem. The test includes setting the vacuum sensor trip point and measuring the chamber pump down speed.

Test equipment

200 liter per minute vacuum pump
Varian 801 vacuum thermocouple meter (or equivalent)
Vacuum hose tee with a Varian TYPE 0531 (or equivalent) thermocouple gauge installed

Test conditions

No liquid samples may be in the sample chamber.

Procedure

1. Install the tee in line with the vacuum pump hose. Connect the vacuum pump hose and power cord to the QuanX rear panel.
1. Connect the meter to the thermocouple mounted in the tee.
1. Open the left top cover and bypass its interlock switch by pulling up on its actuator.
1. Set SW3, the VAC SET switch on the chamber control board as follows:

   1 - 5 ON (down)
   6 - 8 OFF (up)

   The VACUUM OK LED on the left end of the chamber control board should be off.
1. Start an acquisition with vacuum atmosphere, zero seconds live time, and any other conditions. The pump should turn on and the computer should be displaying a "Waiting for vacuum" message.
1. Watch the vacuum gauge meter and the VACUUM OK LED, note the pressure when the LED turns on. If the pressure is between 750 and 1000 millitorr (microns), go on to step 8.
1. If the trip point pressure wasn't correct, change the setting on SW3 one segment at a time and repeat the test. Setting more segments ON (down) causes the trip point to occur sooner (higher pressure) and setting more segments OFF (up) causes the trip point to occur later (lower pressure).
1. Stop the acquisition and allow the chamber to vent. Open and close the chamber lid.
1. Restart the acquisition, note the time. The chamber must begin pumping by itself, *without* pressing on the lid. If it doesn't, the chamber lid or baseplate must be adjusted.
1. Note the time when the VACUUM OK LED turns on.
1. **Verify that the VACUUM OK LED turned on in 90 seconds or less. Verify that the pressure is less than 500 millitorr within 10 minutes.**

7.22 System Status Voltages

Scope and purpose

To verify that all the system status voltages are reading within the normal range. This not only checks several instrument parameters, it also tests the voltage measurement circuit.

Test equipment

Printer

Test conditions

Complete, fully functional system

Procedure

1. Start an acquisition with the following parameters:

Tube voltage	25 kV
Tube current	1.98 mA
Filter	Cu thin
Livetime	0 sec
Preset count	0
Max energy	20 keV
Atmosphere	Air
Warmup	0 sec

1. Press ACQU MENU, SYS STAT, and GEN STAT.
1. Wait 30 seconds to allow each value to be updated twice. Verify that all the values are within the range specified on the screen. The X-RAY H.V CONTROL and X-RAY H.V. MONITOR should be between 24.30 and 25.70 kV. The X-RAY TUBE ANODE CURRENT should be between 1.88 and 2.08 mA.
1. Press HARD COPY to obtain a printout of the values. File this printout in your maintenance log for future reference.
1. If the system is equipped with an ECD, press EXIT and ECD STAT. Wait 30 seconds and verify that all the values are within the range specified on the screen.
1. Press HARD COPY to obtain a printout. File the printout for future reference.

7.23 Helium Flush Operation

Scope and purpose

To perform a basic operational test and a high pressure stress test of the helium flush feature. This test is only applicable if the system is equipped with this option.

Test equipment

10-80 psi variable-pressure compressed air source.
Flow meter p/n 5305-0003 (Matheson Gas 7263) or equivalent (if meter not available, see alternate procedure below).

Test conditions

The helium flush manifold must have been adjusted per its subassembly level test procedure.

Procedure

Note
This is a relative performance test designed to compare the instrument's performance against an expected value. Because the flow is measured on the supply side of the internal pressure regulator, the flow rate values specified are only valid at the specified pressure and also do not represent the true flow rate.

1. Set the compressed air source to 80 psi.
1. Insert the flow meter in the compressed air line. Connect the compressed air to the rear panel HELIUM input nipple.
1. Verify that the flow meter reads zero flow.
1. Start an acquisition with HELIUM atmosphere, 0 seconds LIVETIME and any other conditions.
1. **Verify that the flow meter reads 7.0 ± 1.0 SCFH during the 2 minute purge.**
1. **Verify that the flow meter reads 1.5 ± 0.5 SCFH during the analysis.**
1. Reduce the air pressure while the analysis is running. The computer should display a helium "Low pressure" warning message when the pressure is in the 10-15 psi range.
1. Reset the pressure to 80 psi and restart the acquisition. Wait until the purge stops and the acquisition begins. Press EXIT to stop the acquisition and verify that the flow rate is zero.

Alternate procedure

If a flow gauge is not available, a simple test of the basic operation may still be performed.

1. Set the compressed air source to 80 psi.
1. Connect the compressed air to the rear panel HELIUM input nipple.
1. Start the ECHOA program using the proper argument for QuanX communications by typing

   C>ECHOA Q

1. Open the sample chamber lid.
1. Turn on the helium low flow valve by typing CDO ↵ CX ↵.
1. Listen carefully for the sound of air flowing inside the sample chamber.

1. Turn off the low flow valve by typing CDF ↵ CX ↵. The air flow should stop.
1. Turn on the helium high flow valve by typing CHO ↵ CX ↵.
1. Listen for the air flow sound again. This time is should be significantly louder than before. The high flow rate should be about three times the low.
1. Turn off the high flow valve by typing CHF ↵ CX ↵. The air flow should stop.
1. Turn on the helium low flow valve again by typing CDO ↵ CX ↵.
1. Check the pressure switch state by typing QU ↵. The response should be AUL (low flow valve on). Start reducing the air pressure while typing QU ↵. At a pressure between 10-15 psi, the response should change to AUX (low pressure). Test complete.

7.24 Detector Temperature Measurement (ECD)

Scope and purpose

To measure the temperature of the X-ray sensor located inside the detector housing. It is intended for those occasions when viewing the readout on the ECD STAT screen of the QUANX program is inappropriate. This procedure only applies to systems equipped with the optional electrically cooled detector.

Test conditions

Allow approximately two hours after turning on the coolers for the detector to reach operating temperature.

Test equipment

DMM

Procedure

1. Turn off the power switch. Wait two minutes for the bias voltage to decay, then disconnect the preamp cable from the bias supply.

1. Measure the sensor resistance between pins 10 and 4 of the preamp cable using a DMM. The resistance should be 760 ohms or lower for the detector to operate properly. The table below may be used to determine the detector temperature.

Resistance (Ω)	Temperature (°C)
723	-100
743	-90
783	-80
823	-70
903	-50
1002	-25
1100	0
1197	+25

7.25 Beryllium Window Cleaning Procedure

Scope and purpose

This procedure is intended for use only when absolutely required, such as when the instrument is useless for analytical purposes due to window contamination. It should not be performed as routine or preventative maintenance. Be sure to read the precautions carefully as a very real risk of serious and expensive instrument damage exists. Please contact the Spectrace Instruments Customer Service department for advise and assistance if any questions remain after reading the procedure.

The procedure is presented in two parts: one for the X-ray detector window and one for the X-ray tube window.

Conditions

No open flames or other ignition sources may be in the area.

Required equipment

Laboratory grade aerosol can of air
Methanol in a small squirt bottle

Safety precautions

The beryllium window on the X-ray detector assembly is approximately 0.00035 inches (9 microns) thick, about one-tenth the thickness of this sheet of paper. It is also under one atmosphere of pressure since the detector housing is evacuated. **THE WINDOW IS HIGHLY FRAGILE AND WILL BE DESTROYED BY ANY PHYSICAL CONTACT**. Do not attempt to clean the window with a cotton swab or to pick debris off of it using tweezers.

Beryllium metal is also very susceptible to corrosion from water, acid, or other caustic substances. Corrosion destroys the vacuum integrity of the window. Do not use cleaning solvents other than those specified without contacting the Customer Service department first.

Rupture of the window destroys the detector assembly necessitating its complete replacement. Replacement due to window damage is not covered under warranty or service contract and costs several thousand dollars.

Warning
Beryllium metal is highly toxic if ingested. Do not touch or otherwise handle the foil. If the window is ruptured, follow the emergency measures in Section 2.4, Poisoning Hazard – Beryllium Window.

Warning
Methanol is extremely flammable and toxic. Remove all ignition sources from the area before beginning this procedure. Follow all local site regulations regarding chemical handling.

Procedure - X-ray detector window

1. Remove the sample tray and the metal plate covering the components of the sample chamber.
1. Remove the two socket head screws holding the filter wheel assembly in place. Move the assembly to the side, it is not necessary to disconnect its cables.
1. Loosen the nylon screws holding the detector collimator in place. Gently remove the collimator.

1. If the contamination is particulate in nature (rather than liquid or oil), an air stream may be sufficient to remove the particles. Use the canned air to blow a stream of air **parallel** to the surface of the window as much as possible, as shown in Figure 7-10. Start with the nozzle about 6 inches (15cm) away and slowly move it closer to the window until the particles are removed. Do not allow the nozzle to come closer than 2 inches (5cm) to the window.
1. If the window appears clean, replace the collimator and filter wheel assembly. The flat portion of the collimator snout should be horizontal.
1. If an air stream is not sufficient to clean the window, a liquid wash is required. Place an absorbent towel in the sample chamber, under the window area.
1. Using the squirt bottle of methanol, direct a fine stream of liquid at the **metal** area above the window, as shown in Figure 7-10, and allow the liquid to run over the window. **Do not allow the stream to strike the beryllium material directly!**
1. Dry the window using the canned air as described above. This process may be repeated if required.
1. If the window still isn't clean, a stronger solvent or factory assistance is required. Please contact the Customer Service department for advise.
1. Replace the collimator and filter wheel assembly.

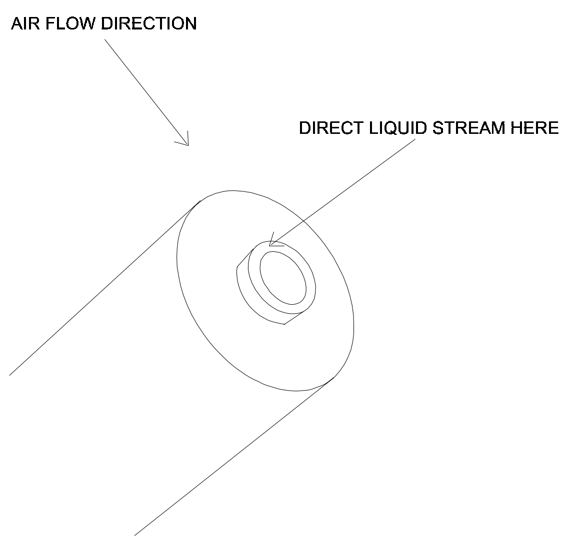


Figure 7-10 Window cleaning detail, LN version shown

Procedure - X-ray tube window

The X-ray tube window is approximately 10 times the thickness of the detector window. Therefore it is not as fragile as the detector window but caution must still be exercised.

1. For particulate matter removal without removing the X-ray tube, a small vacuum may be used. Remove the metal plate covering the sample chamber components. Remove the two socket head screws holding the filter wheel assembly in place. Move the assembly aside, it is not necessary to disconnect its cables.

1. Lower the vacuum nozzle to the X-ray tube collimator opening. Do not allow the vacuum nozzle to seal completely against the collimator surface.
1. If vacuuming is not sufficient to clean the window, remove the X-ray tube by following the procedure in Section 9, Component Replacement.
1. Remove the collimator from the tube. The collimator is not fastened on, it may have remained in the chamber wall when the tube was removed.
1. Follow the procedure outlined above for the detector window. Hold the tube with the window down so the liquid drains out.
1. Replace the tube and other components.

8. Diagnostic Software

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8.1 Introduction

Diagnostic programs allow the service technician to evaluate the performance of various subsystems of the QuanX. This capability makes them useful tools for verifying proper instrument operation as well as malfunctions.

The system status pages within the QUANX program provide system diagnostics. Both pass/fail status messages and numerical values for various system parameters, such as voltages and temperatures, are displayed on these pages. By viewing them, the technician may quickly spot abnormal conditions. Access to these pages is described in the QuanX Operators manual.

This section describes the test procedure files located on the diagnostic diskette, and the ECHOA program. The test procedure files contain preset instrument parameters for some of the tests in Section 7, Test and Adjustment Procedures. ECHOA is a program which allows various instrument functions to be individually exercised. A procedure for installing these programs on the computer's hard disk is also included.

Operation of the computer may be evaluated with the DOS diagnostic programs normally supplied with it. Instructions for these programs are contained in the computer's operation manual.

8.2 Diagnostic Disk Installation

Scope and purpose

The diagnostic diskette supplied with this manual contains files with preset parameters for various system tests. The disk contents should be installed on the fixed disk and the master diskette kept as a backup. This is especially important for the test procedure files since they can accidentally be altered during testing.

Required equipment

8150-0129 Diagnostic diskette

Procedure

The disk contents will be copied to two new directories called C:\SPECTRAC\QTESTLN and C:\SPECTRAC\QTESTECD.

1. Exit the QUANX program if required to return to the DOS prompt.
1. Insert the diagnostic diskette in drive A.
1. Start the installation program by typing

   C>A:INSTALL
1. When the contents have been copied, remove the diskette and store it in a safe place.

8.3 ECHOA PROGRAM

The ECHOA program allows the service technician to exercise various instrument hardware functions by sending simple ASCII text commands to the chamber control board. This capability is useful for troubleshooting specific hardware malfunctions.

The ECHOA program is supplied on the QUANX program diskette and the diagnostic diskette. After installation of the QUANX program, ECHOA will be located in the SPECTRAC directory. To run the ECHOA program, the computer and the RS-232 serial communication path to the control board must be operational. ECHOA obtains the information required to initialize the computer's serial communication port from a system configuration file. This file is created and modified by use of the TXCONFIG program. When ECHOA is executed, the communications port address and interrupt level are displayed. At this time the operator may specify new values for ECHOA to use during the communication session. The default setting for COM1 and IRQ4 are always used. For reference, the RS-232 parameters are: 9600 baud, 8 data bits, 1 stop bit.

8.3.1 Starting the ECHOA Program.

1. Exit the QUANX program if required to return to the DOS prompt.

1. Type the program name followed by the “Q” argument which sets the program to the baud rate used by the QuanX. For example

   C>ECHOA Q

   Typing ECHOA without the Q argument will cause an instruction menu to appear.

1. When the program has finished loading, press the ENTER key several times. Z1 should appear on the screen indicating that communication with the chamber control board has been established. If the message “NO <CR> FROM CHAMBER” is displayed it means that the communication has not been established. Try pressing ENTER a few times, if Z1 appears ignore the error message. If there is no response, verify that the serial communication cable is connected between the PC COM1 connector and the QuanX. Turn the QuanX power off for 10 seconds and then on again. Verify that the filter wheel and sample tray (if equipped) establish home position correctly; the board will not communicate with the PC until the sample tray initialization is complete.

1. To exit the program press ESC or CRTL C.

8.3.2 Command Language Description

ECHOA commands are entered by typing them on the keyboard. The commands are classified as either action commands or query commands. Action commands initiate actions which change the hardware status, such as moving the filter wheel to a new position. These commands begin with the letter C. Query commands request information on the hardware status, such as the sample tray position. They begin with the letter Q.

Action commands are issued by typing the command for the desired function, pressing the ENTER key, typing CX, and pressing the ENTER key again. Action commands are not executed until the CX command is entered. The following example illustrates an action command to move the filter wheel.

CF3 <ENTER>
CX <ENTER>

A sequence of actions can be initiated by entering several action commands followed by a single CX command. In this case, each command will be executed in a predetermined order.

Query commands are issued by typing the appropriate command for the information desired and pressing the ENTER key, CX is not required. The response to a query will start with the letter “A” for answer. The following example illustrates a query command to determine the filter position.

QF <ENTER>

evokes the response

AF3

indicating that the filter is in the logical position 3 (physical position 4).

8.3.3 ECHOA Command List

Command (action)	Name	Usage	Error Response	Usage Description
CA	Vacuum pump control	CAO CAF	EHO	Turn vacuum pump ON Turn vacuum pump OFF
CB	Sample spinner control	CBO CBF		Turn sample spinner ON Turn sample spinner OFF
CCI	Set tube current	CCIxx	MAX	Set tube current to (0.xx)*x*2 mA xx = 00 to 99 (QuanX doubles xx value)
CCH	Set high voltage	CCHxx	MAX	Set tube voltage to xx kV xx = 04 to 50
CD	Low flow helium control	CDO CDF	EAO	Turn low flow helium ON Turn low flow helium OFF
CF	Set filter position	CFx	MAX	Set filter to pos. x + 1. x = 0 -7
CH	High flow helium control	CHO CHF	EAO	Turn high flow helium ON Turn high flow helium OFF
CL	Turn OFF/ON coolers	CLO CLF		Coolers ON Coolers OFF
CP	X-ray power	CPO CPF	*INT,ETF, ELID	X-ray power ON X-ray power OFF

Command (action)	Name	Usage	Error Response	Usage Description
CR	Chamber vent control ("up to air" valve)	CRO CRF		Turn vent valve ON Turn vent valve OFF
CS	Set sample tray position (0127 & 0128 ROM)	CSxx	MAX	Set tray to pos. x + 1. x=0 - 19
CS	Set RTheta linear position (0129 ROM)	CSxxx	MAX	Set linear position to (xxx)*(0.00694) inches forward from home (000 = home)
CT	Chamber lid latch control	CTO CTF	ELID EPO	Lock chamber lid Unlock chamber lid
CX	Execute command			Executes all C_ commands since last CX.
CY if supported	Set RTheta rotation position (0129 ROM only)	CYxxx	MAX	Set rotation position to xxx degrees (000 = home)
CZ	Enable/disable Interlock Interrupt	CZO CZF		Enable interrupt Disable interrupt

Command (query)	Name	Usage	Response	Response Description
QA	Vacuum status		AAO AAF AAW	Pump ON & chamber vacuum good Vacuum pump OFF Vacuum pump ON & chamber vacuum not good, WAITING for vacuum
QB	Sample spinner status		ABO ABF	Sample spinner ON Sample spinner OFF
QCH	X-ray tube high voltage		Axx	Tube voltage = xx kV
QCI	X-ray tube current		Axx	Tube current = (0.xx)*x*2 mA
QD	Helium low flow status		ADO ADF	Low flow valve is ON Low flow valve is OFF

Comman d (query)	**Name**	**Usage**	**Respons e**	**Response Description**
QE	All ECD status		EExx	Convert xx from ASCII to binary, then: Bit # Item Bit=0 Bit=1 0 coolers ON OFF 1 heat sink OK HOT 2 ext. cooler V OK HIGH 3 ion pump ON OFF 4 ion pump curr. OK HIGH 5 ecd installed YES NO 6 & 7 not used
QEA	ECD installed status		AAO AAF	ECD is installed ECD is not installed
QEB	ECD external cooler voltage status (base drive)		ABO ABF	Cooler voltage is OK Cooler voltage is HIGH
QEC	ECD coolers status		ACO ACF	Coolers ON Coolers OFF
QEH	ECD heat sink temperature status		AHO AHF	Heat sink OK Heat sink HOT
QEI	ECD ion pump current status		AIO AIF	Ion pump current is OK Ion pump current is HIGH
QEP	ECD ion pump power status		APO APF	Ion pump is ON Ion pump is OFF
QF	Filter position		Ax AFF	Filter is at position x + 1 Error in filter initialization
QG	LN level status or ECD detector temperature status		AGO AGF	LN level or ECD temperature is OK LN level is LOW or ECD temp. is HIGH
QH	Helium high flow status		AHO AHF	High flow valve is ON High flow valve is OFF
QI	Interlock status		AIO AIF AIX	Interlock CLOSED Interlock OPEN Interlock FAILED to open when the chamber lid was opened.

Comman d (query)	**Name**	**Usage**	**Respons e**	**Response Description**
QJ	Warning light ON sense		AJO AJF	Light is ON Light is OFF
QK	X-ray confirm signal (actual hardware check)		AKO AKF	X-ray power is actually ON X-ray power is actually OFF
QL	ECD cooler control status (see QEC also)		ALO ALF	Coolers are set ON Coolers are set OFF
QM	ROM ID. # + rev.		xxxxy	Rom Id. # = 8140-xxxx y = revision letter (A to Z)
QN	Number of sample tray positions		Axx ANO	xx = Number of tray positions supported No sample tray drive installed
QP	X-ray control status (see QK also)		APO APF	X-rays are set ON X-rays are set OFF
QQ	Warning light current status		AQO AQF	Current is OK Current is HIGH
QR	Chamber vent status ("up to air" valve)		ARO ARF ARW	Vent is OPEN (chamber open to air) Vent is CLOSED Vent is OPEN but chamber is still under vacuum, WAITING for air
QS	Sample tray position (0127 & 0128 ROM)		Axx ASF	Sample tray is in position xx + 1 Sample tray drive option is not installed
QS	R-Theta linear position (0129 ROM)		Axxx	Linear position is (xxx)*(0.00694) inches forward of home.
QS	X-Theta linear position (future ROM)		Axxx ASF	Option is not offered at the time of this manual publication. Linear motor not connected or linear axis failed to locate home position.
QT	Chamber lid lock sense (actual hardware check)		ATO ATF	Lid is locked Lid is not locked

Command (query)	Name	Usage	Response	Response Description
QU	Helium flush status		AUF AUL AUH AUB AUX	Helium flush is OFF Low flow valve is ON High flow valve is ON Both low and high flow valves are ON Helium option not installed or incoming pressure is low.
QV00	Read ECD base temperature		Axxxx	Temp (°C) = 69.481358 - 0.177285xxxx + 0.000118(xxxx)^2
QV01	Read ECD board +12V regulator voltage		Axxxx	V = xxxx /100
QV02	Read ECD internal cooler voltage		Axxxx	V = xxxx /100
QV03	Read ECD heat sink temperature		Axxxx	Temp (°C) = 69.481358 - 0.177285xxxx + 0.000118(xxxx)^2
QV04	Read ECD external cooler voltage		Axxxx	V = xxxx /100
QV05	Read ECD battery voltage		Axxxx	V = xxxx /100
QV06	Read ECD ion pump current		Axxxx	µA = xxxx /10
QV07	Read -12V-PS1 (sw)		Axxxx	V = -xxxx /100
QV08	Read X-ray high voltage monitor		Axxxx	kV =0.05(xxxx)
QV09	Read X-ray high voltage control		Axxxx	Control voltage = xxxx /100 kV = (5)(control voltage)
QV10	Read X-ray H.V. power supply source (HV +24)		Axxxx	V = xxxx /10
QV11	Read +12V-PS3 (lin)		Axxxx	V = xxxx /100
QV12	Read +24V-PS4 (lin)		Axxxx	V = xxxx /10

Command (query)	**Name**	**Usage**	**Response**	**Response Description**
QV13	Read detector bias 1V test point		Axxxx	V = xxxx /1000
QV14	Read -12V-PS3 (lin)		Axxxx	V = -xxxx /100
QV15	Read -24V-PS4 (lin)		Axxxx	V = -xxxx /10
QV16	Read +5V-PS1 (sw)		Axxxx	V = xxxx /100
QV17	Read +12V-PS1 (sw)		Axxxx	V = xxxx /100
QV18	Read +24V-PS2B (sw)		Axxxx	V = xxxx /10
QV19	Read "INTEROUT" interlock signal		Axxxx	V = xxxx /10
QV20	Read ECD stack temperature (+)		Axxxx	Stack temperature (K) = 0.2784(xxxx - yyyy) - 14.65
QV21	Read ECD stack temperature (-)		Ayyyy	
QV22	Read X-ray tube anode current		Axxxx	mA = (xxxx - 100) / 500
QV23	Read ambient temperature		Axxxx	Temperature (°C) = (92.5)(0.9982) xxxx
QW	Chamber lid closed sense		AWO AWF	Chamber lid is CLOSED Chamber lid is OPEN
QY if supported	RTheta rotation position		Axxx AYF	Rotation position is xxx degrees from home. Rotation motor is not installed or rotation axis failed to locate home position.
QZ	Interlock interrupt status		AZO AZF	Interrupt ENABLED Interrupt DISABLED

8.3.4 Error or Other Messages From the Chamber Board

MESSAGE	DESCRIPTION
HI	Does not understand the input command.
*RST	Indicates that a board reset has occurred.
Z1	Input command must start with letter C or Q.
MAX	Too many characters in the input command or the sample/filter position or tube voltage/current is too high.
END	ADC "Conversion Complete" signal never detected when attempting to read a voltage.
OVR	Answer received from reading a voltage is over range.
*INT	Interlock interrupt has occurred.
ERO	Chamber vent valve is open.
ERF	Chamber vent valve is closed.
EHO	Helium flush is on.
EAO	Vacuum pump is on.
ETF	Chamber lid is not locked.
ELID	Chamber lid is open.
EPO	X-rays are on.
ERX	R-Theta stage linear axis failed to establish home position.
ERY	R-Theta stage rotation axis failed to establish home position.

8.3.5 General Usage Notes

Inconsistent chamber atmosphere requests such as vacuum and vent on at the same time are corrected automatically by setting the vent valve to the appropriate state (no error message). Requesting vacuum and helium operation at the same time generates an error message.

The chamber lid must be closed before locking the latch, if it is not an error message will result. The latch should be locked before turning on the X-rays and the X-rays should be off before unlocking the latch. If these are not executed manually, the chamber board program will carry them out automatically (no error message).

The interlock interrupt should be reenabled every time an interlock is broken.

The star messages, *RST & *INT, may be sent by the board at any time; they are not in response to a Q or C input.

Any number of C_ commands may be issued before the execute, CX, command is sent. The operations will be carried out sequentially in a predetermined order. Commands received which generate an error response will not be carried out but any prior commands issued are not disturbed.

8.4 QUANX Service Mode

The QUANX analysis program contains an operational mode useful to the service technician. The instrument contains a number of signals which the computer monitors during normal operation. If an error condition is detected, the program will respond accordingly, quite often discontinuing all operations. Occasionally the service technician will wish to intentionally operate the system in such a way that an error signal is generated. By placing the program in SERVICE MODE, the error will be ignored.

The following error conditions are ignored when operating in SERVICE MODE:

- No counts in the X-ray spectrum.
- ECD coolers are off (future software release).

SERVICE MODE does not disable the X-ray interlock monitor.

One new feature is added while running in this mode. The operator may choose to turn off the automatic zero stabilization feature in the ADC. This is useful for diagnosing energy calibration drifts or for reducing the erratic operation which sometimes occurs when the ADC attempts to compensate for a failure in another component. A new function key labeled ZSTAB OFF is presented on the DETECTOR STATUS screen. After pushing this key the message "Monitor only" will appear on the screen. The zero DAC is held at its present value and the zero offset may be used to monitor the zero drift. To resume automatic zero stabilization, press the ZSTAB ON function key.

To activate the SERVICE MODE, a switch in the TXCONFIG program is set. Run TXCONFIG directly from the DOS prompt by typing:

C>TXCONFIG

From the menus presented select

MODEL QUANX
X-RAY SYSTEM OPTIONS
SERVICE MODE YES

Follow the on-screen prompts and exit and save the changes (see the QuanX Operators manual for more information on the TXCONFIG program).

Execute the QUANX program as normal. It will now be in the SERVICE MODE and the message SERVICE will be displayed at the bottom of the opening screen.

To turn off SERVICE MODE, exit to the DOS prompt. The program will automatically resume normal operation the next time it is executed. To continue using SERVICE MODE, it must be selected again using TXCONFIG.

Caution
Do not leave the instrument operating unattended in SERVICE MODE. Always exit and restart the program to turn off SERVICE MODE after the repair work is completed. Unsupervised operation in SERVICE MODE can lead to inaccurate analysis results and/or instrument damage.

9. Component Replacement

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9.1 Introduction

This section contains procedures for the field replacement of various components in the QuanX. The special precautions section as well as the specific procedure for the component of interest should be read before beginning the actual repair work. This will provide insight on the scope of the task and allow the service technician to properly plan the time and materials required.

9.2 Special Precautions

Beryllium windows

The X-ray tube and ECD detector both have beryllium windows which are extremely fragile and brittle. Since beryllium metal is highly toxic, do not touch or otherwise handle the foil.

DO NOT touch, jar or subject the beryllium windows to mechanical or thermal shock, or to corrosive substances. When installing, replacing, or working around the X-ray tube and the detector assemblies, proceed with great caution.

Refer to Section 2, Safety, for more information on beryllium hazards.

Ion pump power, ECD model only

The ECD detector assembly must be maintained at a high vacuum. This vacuum is maintained by the continuous operation of an ion pump. Power for this pump normally comes from the AC line, or from the internal backup battery if the instrument is not plugged in. A fully charged battery will support the ion pump for 72 hours; do not allow the instrument to remain unplugged longer than this during component replacement operations.

Some of the following procedures require disconnecting power from the ion pump power supply. When ion pump power is lost, the housing vacuum will begin to decrease and within 3 hours it can deteriorate to a level at which the ion pump will not function properly when power is reapplied. Such a condition should be avoided since it can only be corrected by repair or replacement of the ECD assembly. Therefore, plan ahead to carry out these procedures in a timely fashion. Procedures of this nature contain a cautionary statement.

9.3 Circuit Boards

Replacement of the PC boards located in the card cage and elsewhere is detailed below.

9.3.1 Chamber Control Board

1. See Figure 3-4 for the location of this board.
1. Turn off the instrument power switch.
1. For ECD systems, disconnect the instrument power cord. This is required to remove all power from the chamber board socket.
1. Remove the board by pulling out on the two ejection ears located on the top of the board. Lift the board out of the card cage.
1. Set the switches on the replacement board to match the old board settings. SW1 and SW2 are normally both set to the SPINNER position unless the system is equipped with an R-Theta or Y-Theta sample stage, in which case both are set to the THETA position. SW3 sets the chamber vacuum trip point.
1. Install the replacement board by repeating the previous steps in reverse order. Press firmly on the board until it snaps into place.

9.3.2 Pulse Processor

1. See Figure 3-4 for the location of this board.
1. Turn off the instrument power switch.
1. Disconnect the signal cable from the front panel of the pulse processor.
1. Remove the board by pulling out on the two ejection ears located on the top of the board. Lift the board out of the card cage.
1. Install the replacement board by repeating the previous steps in reverse order. Press firmly on the board until it snaps into place.
1. Set the GAIN switch to the “1” position.
1. Perform the following procedures:

    a) 7.2, Fast Discriminator Adjustment
    b) 7.9, Initial Energy Calibration
    c) 7.10, Gain vs. Count Rate Range Adjustment (check only)
    d) 7.3, Energy Calibration
    e) System standardization should be checked before beginning quantitative analysis.

9.3.3 Bias Supply Board

1. See Figure 3-4 for the location of this board.
1. Turn off the instrument power switch.
1. Wait one minute, then disconnect the preamplifier and signal cables from the front panel of the module.
1. Remove the board by pulling out on the two ejection ears located on the top of the board. Lift the board out of the card cage.

1. Verify that the replacement board bias voltage selection wire is plugged into the same socket as the old board (normally 600V for LN and 300 or 400V for ECD). The jumper is a yellow wire located under the metal shield.
1. Install the replacement board by repeating the previous steps in reverse order. Press firmly on the board until it snaps into place.
1. Perform the following procedures:
    a) 7.2, Fast Discriminator Adjustment
    b) 7.3, Energy Calibration
    c) System standardization should be checked before beginning quantitative analysis.

9.3.4 ADC Board

1. See Figure 3-4 for the location of this board.
1. Turn off the instrument power switch.
1. Disconnect the ADC interface cable from the top of the board.
1. Remove the board by pulling out on the two ejection ears located on the top of the board. Lift the board out of the card cage.
1. Install the replacement board by repeating the previous steps in reverse order. Press firmly on the board until it snaps into place.
1. Perform the following procedures:
    a) 7.2, Fast Discriminator Adjustment
    b) 7.9, Initial Energy Calibration
    d) 7.3, Energy Calibration

9.3.5 Display Board

1. Turn off the instrument power switch.
1. Disconnect the “X-RAY ON” warning light cable from the rear panel.
1. Open the sample chamber lid. Remove the ten phillips-head screws which attach the lid outer cover to the metal portion of the lid.
1. With the lid open, gently lift the outer cover up and away from the metal portion of the lid (if closed, the lid will spring open rapidly due to the reduced weight). The warning light cable will remain attached to the cover; the cable connector must be routed through the cutouts in the lid hinge to finally free the cover.
1. Remove the four screws holding the board in place. Disconnect the cable from the board.
1. Install the replacement board and cover by repeating the previous steps in reverse order. Verify that the lead lining in the front of the lid is as close against the casting as possible. This is important to prevent an electrical short circuit to the back of the board.
1. Start an acquisition. If the light fails to illuminate or if the computer gives a warning light related error message, try starting the acquisition with the outer cover pulled forward or lifted slightly to determine if the lead is shorting to the board.

9.3.6 X-ray Control Board

1. See Figure 3-2 for the location of this board.
1. Turn off the instrument power switch.
1. For ECD systems, disconnect the instrument power cord. This is required to remove all power from the board.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Disconnect all the cables from the board.
1. Remove the screws holding the board in place, remove the board.
1. Verify that the kV selection switch on the replacement board is set as on the old board (50kV).
1. Install the replacement board by repeating the previous steps in reverse order. Each connector is unique but some can be installed one pin off, make sure all the pins align.
1. Perform the following procedures:
    a) 7.7, X-ray Power Supply Control Board Adjustment (check only)
    b) 7.20, Voltage and Current Steps
    c) 7.12, Stability

9.3.7 ECD Control Board

CAUTION
This procedure will cause the ECD ion pump to turn off. The procedure should be carried out in 30 minutes or less.

1. See Figure 3-5 for the location of this board.
1. Turn off the instrument power switch and disconnect the instrument power cord. This is required to remove all power from the board.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Disconnect all the cables from the board.
1. Remove the screws holding the board in place, remove the board.
1. Install the replacement board by repeating the previous steps in reverse order.
1. Plug in the power cord and turn on the power. Tap firmly a few times on the ECD ion pump with a screwdriver handle or similar object to ensure that the ion pump has "started." See Figure 4-3 for the location of the ion pump.
1. Turn on the COOLER switch located on the board. All the LEDs near the switch except the EXT COOL ON LED should be on. The EXT COOL ON LED should turn on within ten minutes.
1. Use the ECD STAT screen to check that the voltages and temperatures are within the normal range after the coolers have been on for two hours.

9.3.8 ADC Interface Board

1. This board is located inside the personal computer.
1. Turn off the computer power.
1. Disconnect the ADC interface cable from the rear of the board.
1. Open the computer case. Remove the screw securing the board in place and remove the board.
1. Set the SW1 switch segments on the replacement board to match the old board. Verify that SW2 is also set the same.
1. Install the replacement board by repeating the previous steps in reverse order.
1. Test the board by acquiring a spectrum. Verify that the peaks look normal and that there are no extra or missing lines in the spectrum.

9.4 Power Supplies

Replacement of all the system power supplies is detailed below. It is possible to replace the entire power supply tray as one assembly however these procedures address each supply individually.

9.4.1 X-ray High Voltage Power Supply

1. See Figure 3-2 for the location of this supply.
1. Turn off the instrument power.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Disconnect both cables from the front of the supply. The locking tabs on the sides of the lower connector must be depressed to remove it. Do not touch the end of the high voltage cable or allow it to become dirty. If required, it may be cleaned with isopropyl alcohol.
1. Remove the two screws holding the shield box in place. Remove the power supply/shield box assembly.
1. If the replacement power supply was supplied in a shield box, install it by following the previous steps in reverse order.
1. If the replacement power supply is not in a shield box, remove the four nuts and slide the old power supply from the shield box. Install the new supply in the box, be sure to replace the shoulder washers so that the power supply case is electrically isolated from the shield box. Replace the assembly and connect the cables.
1. Perform the following procedures:

    a) Run at several voltages and verify that the HV MONITOR value on the GEN STAT screen approximately matches the voltage selected.
    b) 7.12, Stability
    c) System standardization is required before beginning quantitative analysis.

9.4.2 PS1 5 & 12V Switching

1. See Figure 7-3 for the location of this supply.
1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Remove the X-ray high voltage power supply as described in Procedure 9.4.1.
1. Remove the screw that secures the front of the power supply tray to the enclosure.
1. Disconnect the two white in-line connectors, J5 & J6, located on left side of the power supply tray. This allows the tray to slide forward farther.
1. Flip up the radiation shield. Slide the tray forward. Free cables as required to allow about 1/3 of the tray to protrude.
1. Unplug both white connectors from the power supply.

1. Rotate the tray 90 degrees clockwise. Remove the ground lug with two black wires from the top of the power supply.
1. Remove the two screws securing the power supply to the tray.
1. Remove the green/yellow wire safety ground wire from the supply chassis.
1. Install the replacement supply by executing the previous steps in reverse order. For easier access to the +5V adjustment control, do not replace the X-ray high voltage power supply yet. Be sure to not pinch any wires behind the power supply tray when reinstalling it.
1. Turn on the power and measure between TB2-10 and gnd (TB2-8). Adjust the pot located below TB2 to obtain +5.20V ± 0.05V. Check the other voltages per Table 7-1 which is part of Procedure 7.4, Power Supply Test and Adjustment.
1. Install the X-ray high voltage power supply and enclosure cover.

9.4.3 PS2 24V Switching

1. See Figure 7-3 for the location of this supply.
1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Remove the X-ray high voltage power supply as described in Procedure 9.4.1.
1. Disconnect the wires from the front of the supply. Note their location first!
1. Remove the screw that secures the front of the power supply tray to the enclosure.
1. Disconnect the two white in-line connectors, J5 & J6, located on left side of the power supply tray. This allows the tray to slide forward farther.
1. Flip up the radiation shield. Slide the tray forward. Free cables as required to allow about 1/3 of the tray to protrude.
1. Remove the green/yellow wire safety ground wire from the supply chassis.
1. Rotate the tray 90 degrees clockwise. Remove the screws securing the power supply to the tray.
1. Remove the AC supply wires from the terminal block on the rear end of the supply. Note their location first!
1. Install the replacement supply by executing the previous steps in reverse order. Do not install the enclosure cover.
1. Check or adjust the supply outputs per Procedure 7.4, Power Supply Test and Adjustment.
1. Install the enclosure cover.

9.4.4 PS3 12V Linear

1. See Figure 7-3 for the location of this supply.
1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.

1. Remove the X-ray high voltage power supply as described in Procedure 9.4.1.
1. Remove the screw that secures the front of the power supply tray to the enclosure.
1. Disconnect the two white in-line connectors, J5 & J6, located on left side of the power supply tray. This allows the tray to slide forward farther.
1. Flip up the radiation shield. Slide the tray forward. Free cables as required to allow about 1/3 of the tray to protrude.
1. Remove the perforated metal shield from the tray assembly.
1. Disconnect the power supply's AC connector, a white in-line connector labeled J1 located between PS3 and PS4.
1. Rotate the tray 90 degrees clockwise. Remove the screws securing the power supply to the tray.
1. Remove the green/yellow wire safety ground wire from the supply chassis.
1. Install the replacement supply by executing the previous steps in reverse order. Do not install the enclosure cover.
1. Check or adjust the supply outputs per Procedure 7.4, Power Supply Test and Adjustment.
1. Install the enclosure cover.

9.4.5 PS4 24V Linear

1. See Figure 7-3 for the location of this supply.
1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Remove the X-ray high voltage power supply as described in Procedure 9.4.1.
1. Remove the screw that secures the front of the power supply tray to the enclosure.
1. Disconnect the two white in-line connectors, J5 & J6, located on left side of the power supply tray. This allows the tray to slide forward farther.
1. Flip up the radiation shield. Slide the tray forward. Free cables as required to allow about 1/3 of the tray to protrude.
1. Remove the perforated metal shield from the tray assembly.
1. Disconnect the power supply's AC connector, a white in-line connector labeled J1 located between PS3 and PS4.
1. Rotate the tray 90 degrees clockwise. Remove the screws securing the power supply to the tray.
1. Remove the green/yellow wire safety ground wire from the supply chassis.
1. Install the replacement supply by executing the previous steps in reverse order. Do not install the enclosure cover.
1. Check or adjust the supply outputs per Procedure 7.4, Power Supply Test and Adjustment.
1. Install the enclosure cover.

9.4.6 PS5 ECD Cooler Supply

1. See Figure 3-5 for the location of this supply.
1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Disconnect J13 from the motherboard located behind the card cage. This is the cable with a red, orange, and two black wires. Release this cable from any cable clamps all the way back to the ECD board J3 connector.
1. Disconnect J3 from the ECD control board. Remove the two board mounting screws near J3 and free the J3 cable from under the board.
1. Disconnect the ECD cooler supply fan wires from J3-6 (two red) and J3-4 (two black).
1. Remove the four screws which attach the ECD power supply bracket to the top of power supply and remove the bracket and cooling fans assembly.
1. Disconnect the white in-line connector J1 located in the supply's transformer cable.
1. Remove the green/yellow wire safety ground wire from the supply chassis. This is the ground wire with a dedicated screw, not the ground wire using a transformer screw.
1. Remove the two nuts and two socket head screws which secure the power supply to the ECD support tray.
1. Lift the power supply out of the instrument.
1. Install the replacement supply by executing the previous steps in reverse order.
1. Turn on the power and use the ECD STAT screen to verify that the cooler voltages are within the normal range. The external cooler voltage will be high until the ECD has reached operating temperature.

9.4.7 Ion Pump Power Supply

WARNING

Electrical shock hazard. The power supply output is approximately 3000 volts DC. Connect or disconnect the supply's output cable only when the red LED located near the bottom of the supply bracket is off.

CAUTION

This procedure will cause the ECD ion pump to turn off. The procedure should be carried out in 30 minutes or less.

1. See Figure 3-5 for the location of this supply.
1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Disconnect the white in-line connector J1 located in the cable connected to the supply bracket. Verify that the red LED turns off.
1. Disconnect the wires from the battery.
1. Disconnect the cable from the supply's BNC output connector.

1. Remove the two screws below the battery. Lift the supply/battery assembly out.
1. Remove the battery and replace the power supply.
1. Reassemble the components by following the previous steps in reverse order.
1. Plug in the power cord and turn on the power. Tap firmly a few times on the ECD ion pump with a screwdriver handle or similar object to ensure that the ion pump has "started." See Figure 4-3 for the location of the ion pump.
1. Measure the voltage between the supply's ground and I.M. connections (black and violet wires). The voltage is proportional to the ion pump current (1mV = 1μA), it should be between 0.2 mV and 20 mV.

9.5 Sample Chamber Components

Replacement of the motorized assemblies located inside the sample chamber area is detailed below.

9.5.1 Filter Wheel Assembly

1. See Figure 3-4 for the location of this assembly.
1. Turn off the instrument power.
1. Remove the sample tray and the metal plate which covers the sample chamber components (or the special sample handling stage if installed). The cover plate is secured with special vented screws, save these for reuse.
1. Remove the two socket head screws which hold the assembly to the baseplate.
1. Disconnect the motor drive cable and sensor cable from the chamber distribution board J6 and J5. Guide the cables under the sample tray drive assembly (if installed) and remove the filter wheel assembly.
1. Install the replacement assembly by following steps in reverse order. Make sure no cables are near the moving parts under the sample tray drive mounting plate.
1. Verify that the home position is established when the power is turned on. The wheel should rotate, change direction to locate the home flag center, and stop.

9.5.2 Sample Tray Drive Assembly

1. See Figure 3-4 for the location of this assembly.
1. Turn off the instrument power.
1. Remove the sample tray and the metal plate which covers the sample chamber components (or the special sample handling stage if installed). The cover plate is secured with special vented screws, save these for reuse.
1. Remove the four vented socket head screws which hold the assembly to the baseplate.
1. Disconnect the motor drive cable and sensor cable from the chamber distribution board J3 and J4. Lift the assembly out.
1. Install the replacement assembly by following steps in reverse order. Make sure no cables are near the moving parts under the mounting plate.
1. Verify that the home position is established when the power is turned on. The tray drive wheel should rotate, change direction to locate the home flag center, and stop.

9.5.3 Sample Spinner Drive Assembly

1. See Figure 3-4 for the location of this assembly.
1. Turn off the instrument power.
1. Remove the sample tray and the metal plate which covers the sample chamber components (or the special sample handling stage if installed). The cover plate is secured with special vented screws, save these for reuse.
1. Remove the four vented screws which hold the assembly to the baseplate.

1. Disconnect the motor cable from the chamber distribution board J7. Remove the cable clamp screw securing the motor cable to the baseplate (near the detector snout).
1. Guide the cable under the sample tray drive assembly. Lift the spinner drive assembly out.
1. Install the replacement assembly by following steps in reverse order. Make sure no cables are near the moving parts under the sample tray drive assembly mounting plate.
1. Verify that the motor turns for approximately ½ second immediately after the power is turned on.

9.6 Detector Assemblies

Replacement of the liquid nitrogen or electrically cooled detector assemblies is detailed below. The procedures are broken up into Removal and Installation sections to more clearly describe certain steps.

9.6.1 LN Detector

CAUTION
The detector's beryllium window is extremely fragile. Read the precautions at the beginning of this chapter before continuing.

Removal

1. Turn off the instrument power.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Remove the screws securing the top left frame member to the chassis and remove the frame member.
1. Remove the single screw which holds the dewar mounting frame to the bottom of the chassis.
1. Disconnect the preamp cable connector from the bias supply board located in the card cage.
1. Remove the sample tray and the metal plate which covers the sample chamber components (or the special sample handling stage if installed). The cover plate is secured with special vented screws, save these for reuse.
1. Remove the two socket head screws which fasten the filter wheel assembly to the baseplate. Move the assembly aside, it is not necessary to disconnect its cables.
1. Remove the sample spinner drive assembly (if installed) screws and move it aside. It is not necessary to disconnect its cable.
1. Remove the four screws which attach the detector to the sample chamber baseplate. These screws have nylon insulators under them and are accessed from *inside* the sample chamber. DO NOT remove any screws from the detector assembly itself as this will break its vacuum seal. Support the detector neck area with one hand while removing the last screw.
1. Grasp the dewar and the neck and carefully guide the detector out the end of the instrument. Keep an eye on the beryllium end until it clears the chamber area.

Installation

1. Transfer the o-ring from the old unit to the replacement unit (if it didn't come with one installed). If the o-ring is dirty, clean it off and reapply a thin coat of vacuum grease.
1. Transfer the insulator ring from the old unit to the replacement unit. Apply a few spots of vacuum grease to the underside of the insulator ring, align the holes in the ring with the flange screw holes and press it into place. The grease will hold the ring in place, making the final installation easier.
1. Normally the replacement unit will have the dewar mounting frame installed. If so, skip this step. If not, transfer the frame from the old to the new dewar. The insulating nylon shoulder washers must be installed in the same way so that the frame is electrically isolated from the dewar.

1. Transfer the collimator from the old unit to the replacement unit if required.
1. Install the detector assembly. Verify that its flange depresses the interlock switch lever located on the chamber port.
1. Due to variations from part to part, the location of the dewar varies slightly. The design intent is that the flange-to-baseplate screws determine the location, then a leveling set screw is used to support the dewar weight and relieve stress on the neck.

   Turn the set screw on the dewar frame counter clockwise to raise it. Install the four screws which hold the flange to the chamber baseplate. The screws must have nylon shoulder insulators around them. Tighten the screws evenly.
1. Turn the set screw on the dewar frame just until it contacts the floor and starts to lift the dewar. Install and tighten the screw that fastens the dewar frame to the chassis.
1. Before connecting the preamp cable, use an ohmmeter to measure the resistance between the detector body (non-painted area) and chassis ground. There must be no electrical contact (open, or infinite reading). If there is electrical contact, make sure the preamp cable housing isn't touching ground and check that the dewar does not touch the X-ray control board mounting bracket. The cause of the short must be found and corrected before continuing.
1. Connect the preamp cable to the bias supply board.
1. Fill the dewar with LN if necessary (if it was dry, wait two hours before testing). Reassemble the remaining components.
1. Perform the following procedures:

   a) 7.2, Fast Discriminator Adjustment
   b) 7.9, Initial Energy Calibration
   c) 7.3, Energy Calibration
   d) 7.11, Resolution
   e) System standardization is required before beginning quantitative analysis.

9.6.2 Electrically Cooled Detector (ECD)

CAUTION
The detector's beryllium window is extremely fragile. Read the precautions at the beginning of this chapter before continuing.

CAUTION
This procedure will cause the ECD ion pump to turn off. The procedure should be carried out in 30 minutes or less.

Removal

1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Remove the screws securing the top left frame member to the chassis and remove the frame member.
1. Remove the single screw which holds the ECD support tray to the bottom of the chassis.
1. Disconnect the preamp cable connector from the bias supply board located in the card cage.

1. Disconnect the ECD support tray cables from the motherboard connectors J11, J13, and J14 located behind the card cage.
1. Disconnect the J4 connector from the ECD control board.
1. Disconnect the white in-line connector J1 located in the ECD cooler supply's transformer cable.
1. Remove the green/yellow wire safety ground wire from the ECD cooler supply chassis. This is the ground wire with a dedicated screw, not the ground wire using a transformer screw.
1. Loosen the hose clamp holding the air hose to the ECD heat sink shroud. Disconnect the hose.
1. Turn off the ion pump power supply by disconnecting the white in-line J1 connector located near the supply. The red LED located on the lower part of the bracket should turn off.
1. Disconnect the cable from the ECD ion pump.
1. Slide the entire ECD support tray out as one assembly.
1. Remove the sample tray and the metal plate which covers the sample chamber components (or the special sample handling stage if installed). The cover plate is secured with special vented screws, save these for reuse.
1. Remove the two socket head screws which fasten the filter wheel assembly to the baseplate. Move the assembly aside, it is not necessary to disconnect its cables.
1. Remove the sample spinner drive assembly (if installed) screws and move it aside. It is not necessary to disconnect its cable.
1. Remove the four screws which attach the detector to the sample chamber baseplate. These screws have nylon insulators under them and are accessed from *inside* the sample chamber. DO NOT remove any screws from the detector assembly itself as this will break its vacuum seal. Support the detector with one hand while removing the last screw. DO NOT allow the detector assembly to drop. Remove the ECD.

Installation

1. Transfer the o-ring from the old unit to the replacement unit (if it didn't come with one installed). If the o-ring is dirty, clean it off and reapply a thin coat of vacuum grease.
1. Transfer the insulator ring from the old unit to the replacement unit. Apply a few spots of vacuum grease to the underside of the insulator ring, align the holes in the ring with the flange screw holes and press it into place. The grease will hold the ring in place, making the final installation easier.
1. Transfer the collimator and heat sink shroud from the old unit to the replacement unit if required.
1. Install the detector assembly. Verify that its flange depresses the interlock switch lever located on the chamber port.
1. Install the four screws which hold the flange to the chamber baseplate. The screws must have nylon shoulder insulators around them. Tighten the screws evenly.
1. Before connecting the preamp cable, ion pump cable, or ECD board J4 cable, use an ohmmeter to measure the resistance between the detector body and chassis ground. There must be no electrical contact (open, or infinite reading). If there is electrical contact, make

sure the preamp cable housing isn’t touching ground. The cause of the short must be found and corrected before continuing.

1. Connect the preamp cable to the bias supply board.
1. Install the ECD support tray. Verify that its rear tab engaged its mating slot and secure the tray to the chassis with one screw.
1. Connect all the motherboard connectors, the ECD control board J4 connector, the ECD cooler power supply J1 connector and ground wire, and the heat sink hose.
1. Connect the ion pump cable to the ECD ion pump. Connect the ion pump power supply J1 connector. Verify that the red LED turns on.
1. Tap firmly a few times on the ECD ion pump with a screwdriver handle or similar object to ensure that the ion pump has “started.” See Figure 4-3 for the location of the ion pump.
1. Plug the instrument power cord in. Turn on the cooler switch located on the ECD control board. All the board LEDs should be on except the EXT COOL OK, and it should turn on within ten minutes.
1. Replace the remaining components.
1. After two hours turn on the instrument power. Using the ECD STAT screen, verify that the detector temperature is within the normal range.
1. Perform the following procedures:

   a) 7.2, Fast Discriminator Adjustment
   b) 7.9, Initial Energy Calibration
   c) 7.3, Energy Calibration
   d) 7.11, Resolution
   e) System standardization is required before beginning quantitative analysis.

9.7 Miscellaneous Items

Replacement of various parts and subassemblies is detailed below.

9.7.1 X-ray Tube

1. Turn off the instrument power.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Remove the X-ray high voltage power supply as described in Procedure 9.4.1.
1. Detach both hoses from the X-ray tube cooling shroud.
1. Disconnect both connectors from the X-ray tube. Do not touch the end of the high voltage cable or allow it to become dirty. If required, it may be cleaned with isopropyl alcohol.
1. Disconnect the white in-line connector in the shroud temperature sensor cable.
1. Remove the sample tray and the metal plate which covers the sample chamber components (or the special sample handling stage if installed). The cover plate is secured with special vented screws, save these for reuse.
1. Remove the two socket head screws which fasten the filter wheel assembly to the baseplate. Move the assembly aside, it is not necessary to disconnect its cables.
1. While supporting the tube with one hand, remove the two screws holding it in place. These screws are accessed from inside the sample chamber, on either side of the tube collimator. These are special vacuum sealing screws with an integral o-ring, save them for reuse.
1. Remove the X-ray tube and shroud.
1. Loosen the two screws in the shroud and slide the tube out.
1. If necessary, remove the label from the new tube and place it on the outside of the shroud. The label interferes with the tube cooling.
1. Slide the new tube in the shroud and tighten the shroud screws moderately, just until the tube is held tightly.
1. Transfer the collimator from the old to the new tube. Note the collimator is not fastened to the tube, it may have remained in the chamber wall when the tube was removed.
1. Install the tube and shroud by following the previous steps in reverse order. Verify that the tube flange depresses the interlock switch lever located on the chamber port.
1. Perform Procedure 7.12, Stability. If the tube hasn't been operated for a long period, an overnight burn-in at moderate power may be required to improve its stability.

9.7.2 X-ray Tube Cooling Fan

1. See Figure 3-3 for the location of the fan.
1. Turn off the instrument power.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Detach the flexible hose from the fan duct.

1. Disconnect the white in-line connectors located in the fan power lead and the X-ray tube shroud temperature sensor cable.
1. Remove the screws which hold the rubber mounts to the instrument chassis. Remove the fan.
1. Transfer the duct and rubber mounts from the old fan to the replacement fan.
1. Install the replacement fan by following the previous steps in reverse order.

9.7.3 Enclosure Cooling Fan

1. See Figure 3-4 for the location of the fan.
1. Turn off the instrument power. Disconnect the instrument power cord.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Remove the fan temperature sensor from the front of the card cage.
1. Remove all the PC boards from the card cage.
1. The card cage needs to be loose to create access space. Remove the four screws which fasten the card cage to the floor. These are the screws with the large clearance holes in the motherboard. The screws on the right side may be accessed by using a long screwdriver from inside the card cage.
1. Detach the flexible hose from the fan duct.
1. Remove the three rear panel screws that hold the fan to the rear panel. These are not the screws that hold the finger guard, but are the three closest to it.
1. Push the card cage forward and work the fan and duct out of the instrument.
1. Transfer the duct and rubber mounts from the old fan to the replacement fan.
1. Install the fan by following the previous steps in reverse order. When complete verify that the fan screw heads do not touch the card cage. This could transmit vibration to the detector and cause poor resolution.

9.7.4 Sample Chamber Lid Latch Assembly

1. See Figure 3-2 for the location of the assembly.
1. Turn off the instrument power.
1. Remove the four rear panel screws which hold the enclosure cover in place. Remove the enclosure cover by grasping it on the bottom of each side and sliding it directly forward.
1. Disconnect the two switch connectors and the two solenoid power wires.
1. Remove the two screws holding the latch assembly to the chamber baseplate.
1. Install the replacement assembly. Reconnect the solenoid wires (no polarity) and the two switch connectors. For safety considerations, it is important that the connectors are connected to the correct switch. The violet/black cable connects to the front-most (lock sense) switch; the brown/black cable connects to the “lid closed” sense switch.
1. Adjust the latch according to Procedure 7.5. Ignore the portions of the procedure regarding the primary lid interlock switch.

9.7.5 Vacuum Pump Power Relay

1. See Figure 3-6 for the location of the AC distribution box assembly. The relay is located inside this box.
1. Turn off the instrument power. Disconnect the instrument and vacuum inlet power cords.
1. Remove the four real panel screws holding the AC distribution box to the rear panel.
1. Slide the box out. Several screw heads and wires may catch as it is pulled out but it does fit.
1. Remove the box cover panel.
1. The solid-state relay is mounted to the wall. Note the electrical connections before detaching any wires.
1. Remove and replace the relay. Apply heat conductive paste to the new relay before installation. If none is available, use the paste from the old relay.
1. Reassemble the parts by following the previous steps in reverse order.

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10. Troubleshooting

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10.1 Introduction

This section presents information useful to the operator as well as to the service technician. The section begins with a listing of the typical system status indicators produced by a properly functioning system. This is followed by a description of system error messages. These subsections are useful when attempting to determine whether the instrument is functioning correctly or not. The latter portion of this section is dedicated to the location and resolution of failures.

10.2 Nominal Ranges For System Status Values

Introduction

The QuanX monitors an several system parameters. These include actual voltage and temperature measurements, pass/fail sensor signals, and X-ray detector performance indicators. The values of these parameters are shown on various screens called status pages.

The following table specifies the DETECTOR STATUS screen typical, minimum, and maximum values for a properly functioning system. The table is as presented on the computer screen. The values given are the average values observed over several seconds. The GENERAL STATUS and ECD STATUS screens have the nominal range listed on-screen.

The table is only valid when the X-rays are off, the detector coolers have been on at least two hours, and the power has been on at least 15 minutes.

DETECTOR STATUS			
	MINIMUM	TYPICAL	MAXIMUM
PHA STATUS		idle	
BIAS VOLTAGE		on	
AMP COUNT RATE		low, med, high	
% DEAD TIME	1	5	20
PREAMP RESETS (/SEC) *LN SYSTEMS:*	0	1 per 10 sec	1 per 3 sec
ECD SYSTEMS:	1	3	10
STORED COUNTS (/SEC)	0	0	0
FAST DISC RATE (/SEC)	100	150	200
ZERO OFFSET (eV)	-4	0	4
ZERO WIDTH (eV)			
LN SYSTEMS:			
LOW RANGE	80	90	105
MED RANGE	95	105	120
HIGH RANGE	160	180	200
ECD SYSTEMS:			
LOW RANGE	80	110	140
MED RANGE	100	130	160
HIGH RANGE	150	190	240
ZERO DAC	-500	0	500
GAIN DAC	-500	0	500
DETECTOR TEMPERATURE (°K) (*ECD SYSTEMS ONLY*)	182	186	190

10.3 Hardware Error Messages

Introduction

Most of the system error messages which are not software related are listed here in alphabetical order. This section is primarily intended for use by the system operator, although the service technician will also find it useful. Each message is followed by an explanation of its meaning, a warning or caution if appropriate, and a cause and remedy chart. The cause and remedy charts have the following features:

- The charts are arranged with the most common causes listed first.
- The remedies are targeted to tasks the operator may complete; for technical troubleshooting tasks the reader is directed to the troubleshooting chart in the next section of this manual.
- A *Technical reference* is supplied for the service technician. The information supplied includes the electrical signal responsible for the specific error message and its location in the system documentation.

ACQ ABORTED: COOLERS ARE OFF

The acquisition was stopped because the X-ray detector coolers are off.

Cause	Remedy
Attempting to run X-rays when detector coolers are off.	Turn detector coolers on before starting an acquisition.
Detector coolers turned off automatically due to high heat sink temperature.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0207 ECD control board, signal "COOLERS ON".

ACQ ABORTED: DET. BIAS VOLTAGE OFF

The acquisition was stopped because the detector high voltage bias is off.

Cause	Remedy
The detector coolers are not on (ECD). The liquid nitrogen level is low (LN).	Turn on the detector coolers or fill the dewar.
The preamp cable is not connected.	Connect the cable to the bias supply in the lower card cage.
Hardware failure.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0194 bias supply board, signal "HV ON".

ACQ ABORTED: ECD THERMAL SHUTDOWN

The acquisition was stopped because the X-ray detector heat sink temperature is high.

Cause	Remedy
Detector heat sink overheated due to low or no air flow.	Check that nothing is blocking the vent openings on the left side of the instrument. See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0207 ECD control board, signal "HEAT SINK OK".

ACQ ABORTED: ION PUMP IS OFF

The acquisition was stopped because the X-ray detector ion pump is off.

CAUTION: Instrument damage may occur if the ion pump is off longer than 3 hours.

Cause	Remedy
Low or failed +12 volt power source for detector ion pump power supply.	See the troubleshooting chart in the next section.

Technical reference:	See schematic 5919-0207 ECD control board, signal "ION PUMP ON".

ACQ ABORTED: STABILIZER LOST ZERO PEAK

The system is not able to correct for zero shifts in the energy calibration.

Cause	Remedy
The ADC requires a logic reset.	Exit the program, cycle the power off and on and resume operation.
Hardware calibration is too far out of adjustment for the system to compensate.	Adjust the hardware calibration per Procedure 7.9, Initial Calibration.
Hardware failure.	See the troubleshooting chart in the next section.

ACQ ABORTED: ZERO DAC AT LIMIT

The system is not able to correct for zero shifts in the energy calibration.

Cause	Remedy
The ADC requires a logic reset.	Exit the program, cycle the power off and on and resume operation.
Hardware calibration is too far out of adjustment for the system to compensate.	Adjust the hardware calibration per Procedure 7.9, Initial Calibration.
Hardware failure.	See the troubleshooting chart in the next section.

ACQUISITION FAILED TO INITIATE

No X-ray counts were detected during the first second of the acquisition.

Cause	Remedy
Excitation voltage set too low for the filter selected.	Raise the X-ray kV setting or choose a different filter.
No sample in the tray position selected.	Install a sample.
X-ray tube anode current set to zero.	Select a new mA value.
Fast discriminator requires adjustment.	Adjust to 150 ±25 with X-rays off, see Procedure 7.2.
ADC locked up.	Exit program, cycle the power off and on, restart program.
Hardware failure.	See the troubleshooting chart in the next section.

ADC failed to respond. Retry previous task or check hardware and reload program

The computer is not able to communicate with the ADC board.

Cause	Remedy
Random noise event.	Resume normal operation.
ADC locked up.	Exit program, cycle the power off and on, restart program.
ADC interface cable is disconnected or loose.	Turn off the power. Disconnect and reconnect the cable connections at each end.
ADC board not inserted correctly in the card cage.	Turn off the power. Reseat ADC firmly.
Hardware failure.	See the troubleshooting chart in the next section.

CHECK PRINTER

The software detected a printer during boot up but the printer is not "on-line" now.

Cause	Remedy
The printer is off-line.	Put the printer on-line.
The printer is disconnected.	Connect the printer or exit and restart the analysis program with the printer disconnected.

DEAD TIME TOO HIGH - CHANGE PARAMETERS

The dead time is beyond the normal operating range.

Cause	Remedy
The X-ray tube voltage or current is set too high.	Lower the kV and/or mA settings and restart the acquisition.
Improper filter selected.	Select a thicker filter.
Fast discriminator requires adjustment.	Adjust to 150±25 with X-rays off, see Procedure 7.2.
Wrong pulse processor count rate range selected.	Select a higher count rate range.
Hardware failure.	See the troubleshooting chart in the next section.

Chamber failed to respond

The computer is not able to communicate with the chamber control board.

Cause	Remedy
RS-232 serial communications connector is loose or disconnected from the computer.	Check the COM1 connection at the back of the computer.
Chamber control board requires a logic reset.	Cycle the power off and on. Resume operation.
The board is locked up attempting to locate the sample tray home position.	Verify by checking the sample tray after turning on the power. If it never turns or never stops, this is the problem. See the troubleshooting chart in the next section.
Chamber control board not inserted correctly in the card cage.	Turn off the power. Unplug the power cord (ECD systems only). Reseat the board firmly.
Hardware failure.	See the troubleshooting chart in the next section.

Failed to download file to ADC

Not able to write the file INIT5500 into the ADC module because the computer cannot communicate with the ADC. This file contains the ADC operating instructions and is sent to the ADC every time QUANX is executed from DOS.

Cause — Remedy

See the Cause and Remedy for the message: "ADC failed to respond. Retry previous task or check hardware and reload program."

Failed to initialize filters

The filter wheel mechanism failed to establish the home reference position, therefore the X-ray transmission filters cannot be positioned accurately.

Cause	Remedy
Chamber control board requires a logic reset.	Cycle the power off and on, restart the QUANX program.
Hardware failure.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0217 chamber control board, signal “FHD” (filter home detect).

INTERLOCK CIRCUIT FAILURE DETECTED - SERVICE REQUIRED

The chamber board detected a failure in the primary sample chamber lid interlock switch.

Cause	Remedy
Random noise event.	Open the sample chamber lid for one second and close it, start the acquisition. If unsuccessful, turn the power off and on, start the acquisition.
Hardware failure or adjustment required.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0217 chamber control board, signal “LID OPEN” and “INTERLOCK.”

Program too big to fit in memory

DOS error message. DOS is unable to allocate sufficient memory to execute the program.

Cause	Remedy
Attempting to execute QUANX from within another program or shell.	Run QUANX directly from the DOS prompt.
Attempting to execute a large external program from within QUANX.	Exit QUANX and run the external program directly from the DOS prompt.
Insufficient base memory (lower 640k) available.	Computer must have minimum 1meg RAM installed.
	Remove any memory resident programs from memory before running QUANX.
DOS is not loaded into high memory.	DOS 6.0 or higher required. Add HIMEM.SYS and DOS=HIGH commands in CONFIG.SYS file. See Section 5.5.2.
Computer memory failure.	Run PC diagnostics. Replace CPU board or repair as required.

System failed to calibrate - hardware problem

The system was unable to complete energy calibration with a sufficiently small error within 30 minutes. The criteria is a function of the absolute error, the number of counts in the peak, and the peak position stability.

Cause	Remedy
PRESET COUNT set to non-zero value.	Enter ECAL CONFG and set the PRESET COUNT "0".
Count rate is too low.	Raise mA to achieve approximately 50% dead time.

Hardware calibration is too far out of adjustment for the system to compensate.	Adjust the hardware calibration per Procedure 7.9, Initial Energy Calibration.
Fast discriminator requires adjustment.	Adjust to 150 ±25 with X-rays off, see Procedure 7.2.
Hardware problem.	See the troubleshooting chart in the next section.

X-RAYS NOT OFF - HARDWARE PROBLEM. 'Confirm' signal failure

The computer attempted to turn off the X-rays but the chamber control board is reporting that the X-rays are still on.

Cause	Remedy
Hardware failure.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0217 chamber control board, signal "CONFIRM."

X-RAYS NOT ON - HARDWARE PROBLEM. 'Confirm' signal failure

The X-rays should be on but the chamber control board is reporting that the X-rays are off.

Cause	Remedy
Hardware failure.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0217 chamber control board, signal "CONFIRM."

X-RAYS NOT ON - HARDWARE PROBLEM. Interlock has opened

The X-rays should be on but the chamber control board is reporting that the X-rays are off because an interlock has been opened.

Cause	Remedy
An interlock is open.	Check the left top cover and enclosure cover switches, and the mounting switches under the X-ray tube and X-ray detector.
Hardware failure.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0217 chamber control board, signal "INTERLOCKS" and 0110-0632 safety interlock circuit.

X-RAYS NOT ON - HARDWARE PROBLEM. 'Light On' signal failure

The X-rays should be on but the chamber control board is reporting that the X-rays are off because the warning light is not illuminated.

Cause	Remedy
Warning light cable is not plugged in.	Check that the cable located on the rear panel is properly connected.
Hardware failure.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0217 chamber control board, signal "LIGHT ON."

X-RAYS NOT ON - HARDWARE PROBLEM. Warning light current is high

A failure in the X-RAY ON warning light has been detected. X-rays can not be generated until the problem is corrected.

Cause	Remedy
Hardware failure.	See the troubleshooting chart in the next section.
Technical reference:	See schematic 5919-0217 chamber control board, signal "LIGHT HIGH."

10.4 Troubleshooting Chart

10.4.1 Introduction

The following troubleshooting chart is intended for use by a service technician. The chart is alphabetized by failure symptom, with any related error messages listed in italics just below the symptom. An index of all the symptoms, error messages, and key words precedes the troubleshooting chart. This allows the reader to scan the available entries and quickly locate items of interest.

Each failure symptom is followed by a cause, remedy, and reference chart. These charts have the following features:

- The charts are arranged with those causes listed first which occur most often or are easiest to verify.
- The causes and remedies are presented in a logical sequence to assist the troubleshooting effort. The instructions at any given level assume that the previous causes have been investigated and found to not apply. It is important that the technician follow the sequence as presented.
- The *reference* column refers the technician to the appropriate location in the system documentation for more information. Troubleshooting aids such as the schematic number, signal name, and connector pin numbers guide the technician to a logical starting point for the troubleshooting effort. Also referenced are specific procedures documented elsewhere in the manual which are used to carry out the recommended operations.

A moderate level of technical ability and familiarity with the system is assumed. No explicit warnings are given for personal safety or potential damage to the instrument. For this information, read the special precautions listed elsewhere in this manual. For an explanation of the meaning of the error messages, refer to the previous section, Hardware Error Messages.

Some entries are dependent on the type of detector installed in the instrument, LN or ECD. Most of the ECD only related entries are followed by (ECD).

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ACQ ABORTED: ION PUMP IS OFF

Cause	Remedy	Reference
Low or failed +12v power supply on ECD control board.	Measure voltage to confirm. Replace ECD control board.	5919-0207 "IPP (R23)".
Faulty ECD control board generated false signal.	Verify and replace the board.	5919-0207 "ion pump on".

ACQ ABORTED: STABILIZER LOST ZERO PEAK

Cause	Remedy	Reference
The hardware zero setting is too far out of adjustment for the ADC to compensate.	Adjust the zero control on the pulse processor module until the zero DAC is below 200.	Procedure 7.9.
PS1 +5 V power supply is low.	Measure per procedure, or measure the voltage across the small capacitor above the ADC interface cable connector on the ADC. Must be greater than 4.95 V.	Procedure 7.4.1.
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.

ACQ ABORTED: ZERO DAC AT LIMIT

Cause	Remedy	Reference
The hardware zero setting is too far out of adjustment for the ADC to compensate.	Adjust the zero control on the pulse processor module until the zero DAC is below 200.	Procedure 7.9.
PS1 +5 V power supply is low.	Measure per procedure, or measure the voltage across the small capacitor above the ADC interface cable connector on the ADC. Must be greater than 4.95 V.	Procedure 7.4.1.
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.

ADC BOARD DOES NOT COMMUNICATE

FAILED TO DOWNLOAD FILE TO ADC
ADC FAILED TO RESPOND. RETRY PREVIOUS TASK OR CHECK HARDWARE AND RELOAD PROGRAM

Cause	Remedy	Reference
ADC requires a logic reset.	Exit the program, cycle the power off and on, restart the program.	
ADC interface cable is disconnected or loose.	Turn off the power. Reseat the ADC interface cable connections at each end.	Figure 3.6.

ADC board is not inserted correctly in the card cage.	Turn off the power. Reseat the ADC firmly.	Procedure 9.3.4.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.1.
Switch S2 (I/O port address) on the ADC interface board is not set correctly.	Set the switch as specified in the installation procedure.	Procedure 5.5.3.
Faulty ADC interface board.	Verify by substitution, replace if required.	Procedure 9.3.8.

AMBIENT TEMPERATURE INSIDE THE INSTRUMENT IS HIGH

HIGH AMBIENT TEMP. - CHECK SYSTEM STATUS

Cause	Remedy	Reference
Outside ambient temperature is above 32° C.	Reduce the external ambient temperature.	Section 3.3.
Fan inlet on rear panel is blocked.	Verify that there is at least 4 inches of free space behind the inlet.	
Loose or disconnected hose.	Check the enclosure cooling fan flexible hose connections.	
Cooling system clogged with dirt.	Visually inspect the holes under the card cage motherboard.	
Faulty cooling fan.	Blow a heat gun on the sensor located on the front of the card cage. The fan speed should increase. Check for air flow out of the holes in the floor. Replace fan if required.	Procedure 9.7.3 for replacement.
Faulty chamber control board generated a false error signal.	Verify and replace the appropriate board.	Procedure 9.3.1.

BACKGROUND LEVEL IS HIGH

Cause	Remedy	Reference
Analysis conditions and/or method are not optimized for the elements of interest.	Contact a factory applications specialist.	
Fast discriminator requires adjustment.	Adjust the fast discriminator control for 150 ±25 counts/sec with the X-rays off.	Procedure 7.2.
Low detector bias supply voltage.	Verify on the GENERAL STATUS screen. The bias supply 1v should be greater than 0.95. If it is low, replace the bias supply module.	Procedure 9.3.3.
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.

Poor resolution or detector "tailing".	Run resolution test with manganese to check for tailing, 5k peak to background should be greater than 400. If the resolution is ok and the peak to background is low, replace the detector assembly. If the resolution is poor, see: *Resolution is poor*.	
Faulty detector assembly.	Verify by substitution, replace if required.	Procedure 9.6.

CHAMBER CONTROL BOARD DOES NOT COMMUNICATE

CHAMBER FAILED TO RESPOND

Cause	Remedy	Reference
RS-232 serial communications connector is loose or disconnected from the computer.	Check the COM1 connection on the back of the computer.	
Chamber control board requires a logic reset.	Turn the power off for 5 seconds and then back on. Resume operation.	
The enclosure control board is locked up attempting to locate the sample tray home position.	Verify by watching the tray after turning on the power. It should rotate, change direction to locate the flag center, and stop. If it doesn't, see: *Sample tray failed to locate home*.	
Faulty power supply or adjustment required.	Check +5 V (PS1) per procedure. Adjust or replace as required.	Procedure 7.4.1.
Faulty chamber control board.	Verify by substitution, replace if required.	Procedure 9.3.1.
Faulty computer COM1 port.	Perform port loop-back test. Jumper COM1 port pins listed below on computer and run ECHOA Q. Anything typed on keyboard should appear on the screen if the port is working correctly. 9-pin connector: 7-8; 4-6; 2-3 25-pin connector: 4-5; 6-20; 2-3	
Bad connection in the RS-232 cable.	Use an ohmmeter to perform a pin-to-pin check of each connection.	

DEAD TIME IS HIGH

DEAD TIME TOO HIGH - CHANGE PARAMETERS
CHECK DETECTOR STATUS

Cause	Remedy	Reference
If dead time is high with X-rays off:		
Fast discriminator requires adjustment.	Adjust fast discriminator control for 150 ±25 counts/sec with X-rays off.	Procedure 7.2.
ADC interface cable is loose.	Turn off the power. Reseat the ADC interface cable connections at each end.	Figure 3.6.
A board is not inserted correctly in the card cage.	Turn off the power. Reseat all the boards firmly.	

Preamp reset rate (X-rays off) is above 1 reset per 2 sec. (LN) or 10 resets per sec. (ECD).	See: *Preamp reset rate is too high.*	
Detector temperature is above 190 (ECD).	See: *Detector temperature is too high.*	
Ion pump current is above 20 (ECD).	See: *Ion pump current is high.*	
Faulty ADC interface cable.	Verify by substitution, replace if required.	Figure 3.6.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Noise pickup.	See: *Resolution is poor.*	
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.
If dead time is high with X-rays on:		
The X-ray tube voltage or current is set too high.	Lower the kV and/or mA settings and restart the acquisition.	
Improper filter selected.	Select a thicker filter.	
Improper pulse processor count rate range selected.	Select a higher range.	
Faulty ADC interface cable.	Verify by substitution, replace if required. Alternate test: note D.T. while acquiring a spectrum and then select the ACQ. PARAMETERS menu. If D.T. drops when this menu is displayed, it usually indicates a faulty cable (noise is generated when spectral data is transmitted, in acq. par. menu the data transfer is halted).	Figure 3.6.
X-ray control board requires adjustment or is faulty.	Verify with " X-ray control voltage " and "anode current" entries in the GEN STAT screen. Replace if required.	Procedure 7.20 board test. Procedure 7.7 board adjust.
Filter positioning mechanism is faulty.	Verify by exiting and restarting QUANX. An error message will appear if the mechanism doesn't initialize properly. See: *Filters do not position correctly.*	
A failure listed for "X-rays off" is the cause but is only significant with the X-rays on.	See the causes and remedies for high dead time with X-rays off.	

DEAD TIME IS LOW OR ERRATIC

Cause	Remedy	Reference
The X-ray tube voltage or current is set too low.	Raise the kV and/or mA settings and restart the acquisition.	
Improper filter selected.	Select a thinner filter.	
Fast discriminator requires adjustment.	Adjust to 150 ±25 with X-rays off.	Procedure 7.2.
Improper pulse processor count rate range selected.	Select a lower range.	
Detector high voltage bias is off.	Verify that the "HV" light on the bias supply is off, then see: *Detector high voltage bias is off*.	Figure 3.4.
ADC interface cable is loose.	Turn off the power. Reseat the ADC interface cable connections at each end.	Figure 3.6.
A board is not inserted correctly in the card cage.	Turn off the power. Reseat all the boards firmly.	
X-ray control board requires adjustment or is faulty.	Verify with " X-ray control voltage " and "anode current" entries in the GEN STAT screen. Replace if required.	Procedure 7.20 board test. Procedure 7.7 board adjust.
Filter positioning mechanism is faulty.	Verify by exiting and restarting QUANX. An error message will appear if the mechanism doesn't initialize properly. See: *Filters do not position correctly.*	
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Faulty pulse processor board.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.1.

DETECTOR HEAT SINK TEMPERATURE IS HIGH (ECD)

ACQ ABORTED: COOLERS ARE OFF
ACQ ABORTED: ECD THERMAL SHUTDOWN

Cause	Remedy	Reference
Blocked vent opening.	Vent opening on left side must have at least 4 inches clearance.	
Disconnected hose.	Check large flexible hose connected between the heat sink and fan.	
ECD fan power is disconnected, or polarity is reversed, or the fan is faulty.	Check fan cable, J11 on motherboard. Check for 24V of correct polarity at the fan, if good replace fan.	

Faulty ECD control board generated false signal.	Verify and replace the board.	5919-0207, "heat sink ok".
Faulty temperature sensor or bad connection to it.	Sensor resistance ≈ 2250 Ω at 25°C, 1470 Ω at 35°C. Unplug connector to measure.	5919-0207 J4 pins 6&7.

DETECTOR HIGH VOLTAGE BIAS IS OFF

ACQ ABORTED: DET. BIAS VOLTAGE OFF

Cause	Remedy	Reference
Detector preamp cable is disconnected.	Connect preamp cable.	Figure 3-4.
LN dewar is empty.	Fill the dewar, wait 1-2 hours.	
The detector coolers are not on (ECD).	Verify on the ECD STATUS screen. The switch is located on the ECD control board. If the switch is already in the on position, see the following causes.	Figure 3-5.
The detector coolers have not been on long enough (ECD).	Allow 2 hours for the detector to reach operating temperature.	
The detector temperature is too high (ECD)..	Verify on the ECD STATUS screen, detector should be less than 190 K. Or measure per procedure. If high, see: *Detector temperature is too high*.	Procedure 7.24.
The HV light on the bias supply module is off because:	Verify that the light on the bias supply module is off. If it is on, skip the next 4 causes.	Figure 3-4.
The bias supply module is not inserted correctly.	Turn off the power and reseat the board in the card cage.	
Faulty power supply or adjustment required.	Check the ± 12 V (PS3) using the GENERAL STATUS screen or per procedure.	Procedure 7.4.1.
Faulty bias supply module.	Verify by substitution, replace if required.	Procedure 9.3.3.
Faulty detector preamp board.	Verify by substitution, replace if required.	Contact factory.
Bias supply module HV light is on but no bias voltage is generated due to a faulty bias supply module.	Verify on the GENERAL STATUS screen. If good, bias supply 1v is greater than 0.95. If low, replace the bias supply module.	Procedure 9.3.3.

DETECTOR TEMPERATURE IS TOO HIGH (ECD)

Cause	Remedy	Reference
The detector coolers are not on.	Verify on the ECD STATUS screen. An on/off switch is located on the ECD control board. If the switch is already in the on position, see the following causes.	Figure 3-5.
The detector coolers have not been on long enough.	Allow 2 hours for the detector to reach operating temperature.	

The detector heat sink temperature is too high.	Verify on the ECD STATUS screen, heat sink should be less than 40°C. If it is high, see: *Detector heat sink temperature is high*.	
Both the detector temperature **and** the base temperature are high because:	Verify on the ECD STATUS screen, the base should be less than 21°C. If high, see following causes.	
Poor vacuum in the detector housing.	Check the ion pump current on the ECD STATUS screen. If it is above 20, or is 0, see: *Ion pump current is high.*	
External cooler voltage is low because:	Verify on the ECD STATUS screen. When the base temp is high, the ext cooler voltage should be at max. (greater than 7.5 V). The ext. cooler supply has a variable voltage output, if it's low it could be a bad power supply, ECD control board, or sensor (see next 3 causes).	
Faulty cooler power supply.	Test per procedure, replace if required.	Procedure 7.4.2.
Faulty ECD control board.	Verify by substitution, replace if required.	5919-0207 J3-3 "+sense".
Faulty base temperature sensor or bad connection to it.	Sensor resistance ≈ 2250 Ω at 25°C, 3080 Ω at 18°C. Unplug connector to measure.	5919-0207 J4 pins 8&6.
Open circuit in the external cooler power path. (Det. support screen may still read normal.)	The cooler power on/off entry on the DET. SUPPORT screen is generated by the cooler power relay (relay closed = coolers on). If it says "off", the ECD board may be bad (relay not closed). Also measure the cooler voltage at the detector terminal strip (#4 pos, #7 neg.).	5919-0207 J4-4,5 & J3-7,5, relay K1.
The detector temperature is high but the base temperature is normal because:	Verify on the ECD STATUS screen, the base should be less than 21°C. If it is, see following causes.	
Internal cooler current is low.	Verify on the ECD STATUS screen. The int. cooler power supply regulates the current, not the voltage. If the int. cooler voltage is less than 5, the power supply is bad. If it is greater than 7.5 there is high resistance in the path (see next cause). Measure the current, it should be 3.8 A. Test the power supply per procedure.	5101-0369 TB-8 & 3. Procedure 7.4.2.
Open circuit in the internal cooler power path. (Internal cooler voltage ≈ 10 V.)	The cooler power on/off entry on the DET. SUPPORT screen is generated by the cooler power relay (relay closed = coolers on). If it says "off", the ECD board may be bad (relay not closed). Also measure the cooler voltage at the detector terminal strip (#8 pos, #3 neg.).	5101-0369 TB-8 & 3. 5919-0207 J4-3,2 & J3-8,9, relay K1.

Detector temperature is good but false signal generated due to a bad stack sensor or connection.	Measure the detector temperature per procedure.	Procedure 7.24.
Faulty ECD detector assembly.	Verify by substitution, replace if required. If desired, measure the cooler's resistance (off and unplugged) to check their condition. Internal ≈ 2 Ω, external ≈ 1 Ω at room temperature. This is **not** a comprehensive test but will identify a major failure.	Procedure 9.6.2. Int. TB-8 & 3. Ext. TB-7 & 4.

ENERGY CALIBRATION FAILS TO EXECUTE SUCCESSFULLY

SYSTEM FAILED TO CALIBRATE - HARDWARE PROBLEM

Cause	Remedy	Reference
PRESET COUNT set to non-zero value.	Enter ECAL CONFG and set the PRESET COUNT to 0.	
Count rate is too low.	Raise mA to achieve approximately 50% dead time.	
Fast discriminator requires adjustment.	Adjust the fast discriminator control for 150 ±25 counts/sec with the X-rays off.	Procedure 7.2.
Hardware calibration is too far out of adjustment for the system to compensate.	Adjust the pulse processor calibration per procedure.	Procedure 7.9.
Short term peak shift caused by one of the following:	Verify by running the RESOLUTION - STABILITY test. Peak centroid deviation allowed is ± 3 eV max.	Procedure 7.12.
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.1.
Unstable detector resolution.	Verify by running the RESOLUTION - STABILITY test. If peak centroid deviation is good and resolution deviation is > ± 5 eV or is high, see: *Resolution is poor*.	Procedure 7.12.

ENERGY CALIBRATION IS UNSTABLE (LONG TERM PEAK SHIFT)

SYSTEM FAILED TO CALIBRATE - HARDWARE PROBLEM

Cause	Remedy	Reference
Fast discriminator requires adjustment.	Adjust the fast discriminator control for 150 ±25 counts/sec with the X-rays off.	Procedure 72.
Hardware calibration is too far out of adjustment..	Adjust the pulse processor calibration per procedure.	Procedure 7.9.

Long term peak shift (large gain DAC variations between successful calibrations) caused by one of the following:		
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.1.
Faulty detector preamplifier board.	Verify by substitution, replace if required.	Contact factory.

EXTERNAL COOLER VOLTAGE IS HIGH

EXTERNAL COOLER VOLTAGE IS HIGH

Cause	Remedy	Reference
Ambient temperature is high.	Reduce ambient temperature to below 30°C (86°F).	
Blocked ECD fan vent opening.	Vent opening on the left side must have at least 4 inches clearance.	
Enclosure temperature is too high.	See: *Ambient temperature inside the instrument is high.*	
ECD fan inlet duct not sealed against inlet wall.	Loosen screws and adjust the duct so that the rubber seal touches the enclosure cover when it is installed.	
Disconnected or loose ECD heat sink cooling hose.	Check the large flexible hose connected between the heat sink and fan.	
Temperature set point needs adjustment.	ECD board TP2 should be 3.75V (adjust R5). This adjustment sets the “base” temperature.	5911-0207 TP2
ECD cooler power supply needs adjustment.	Set the nominal output level with sense lines shorted to output per procedure. This setting acts as an offset bias to move the output range higher or lower. It doesn’t directly set the detector temperature or cooler voltage.	Procedure 7.4.2.
Faulty ECD control board.	Verify by substitution.	Procedure 9.3.7.
Faulty ECD cooler power supply.	Verify by substitution. Or if desired, test by varying the sense input and verifying that the output voltage changes. R5 on ECD control board may be used but must be reset for 3.75V at TP2.	
Poor housing vacuum causing high heat load.	See: *Ion pump current is high*.	

Faulty ECD assembly.	Verify by substitution.	Procedure 9.6.2.

FAST DISCRIMINATOR CANNOT BE ADJUSTED PROPERLY

Cause	Remedy	Reference
Detector preamp cable is disconnected.	Connect preamp cable.	0150-0111.
Output cable between the bias supply board and the pulse processor board is disconnected.	Connect BNC cable.	
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.1.
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Excessive noise pickup.	See: *Resolution is poor*.	

FILTERS DO NOT POSITION CORRECTLY
FAILED TO INITIALIZE FILTERS

Cause	Remedy	Reference
Mechanical jam.	Check that filter wheel can be rotated one full rotation by hand with the power off.	
Motor or sensor connector is unplugged, or a wire is broken.	Check connections at the chamber distribution board. Motor is J6, sensor is J5.	Figure 3-4.
If motor turns when the power is first turned on, see the following causes:		
"Filter home" signal is not being generated correctly due to:	Verify with FILTER HOME LED on the chamber control board. With the power on, rotate the wheel by hand. As the flag pin passes through the sensor, the LED should turn on (always off otherwise). If bad see the following causes.	5919-0217 "FHD".
Flag is not breaking the light beam.	Verify by inserting opaque paper in sensor. If the FILTER HOME LED turns on only when paper is inserted, the flag pin is missing or is too short.	
Faulty optical home sensor.	To verify: Plug the filter sensor connector J5 into the chamber distribution board J4 (tray sensor position) and rotate the wheel by hand. If the SAMPLE HOME LED lights only when the flag is in the sensor, then the filter sensor is good, go on to next cause; otherwise replace the sensor.	Figure 3-4.
If the motor does not turn when the power is first turned on, see the following causes:		

Faulty chamber control board or stepper motor.	Verify by substitution, or for systems equipped with the sample spinner or theta stage option (second feedthru cable installed in the chamber distribution board J2) see the diagnosis method below. Plug the filter motor connector J6 into the chamber distribution board J7 (spinner drive position), set chamber board SW1 and SW2 to the SPINNER position, run ECHOA Q, type CBO ↵ CX ↵. If the motor turns smoothly, the chamber control board is bad. If the motor doesn't turn, the motor or a connection is bad.	Procedure 9.3.1. Procedure 9.5.1.

HIGH VOLTAGE ARCING

X-RAYS NOT ON - HARDWARE PROBLEM. 'CONFIRM' SIGNAL FAILURE
X-RAYS NOT ON - HARDWARE PROBLEM. 'WARNING LIGHT IS OFF'
ACQUISITION ABORTED - ECD COOLERS ARE OFF

Cause	Remedy	Reference
Note: Arcing can cause a variety of failure symptoms. The error messages listed above are a likely response. Typically, arcing is kV sensitive.	Verify that arcing is the problem by setting the program to service mode via the TXCONFIG program. Run at the lowest kV setting, check that the problem is gone. Better test: all the above plus unplug J4 & J5 from the X-ray control board and jumper J5 pins 4 & 5 on the board.	5919-0161 J4 & J5.
Contaminated high voltage cable.	Remove the cable from the tube and power supply. Clean both ends using isopropyl alcohol and a lint free cloth. Reinstall without touching the clean ends.	
Faulty high voltage cable.	Verify by substitution, replace if required.	
Contaminated high voltage connector on the tube or power supply.	Clean the inside of both connectors using isopropyl alcohol and a lint free swab.	
Faulty X-ray tube.	Verify by substitution, replace if required.	Procedure 9.7.1.
Faulty X-ray high voltage power supply.	Verify by substitution, replace if required.	Procedure 9.4.1.

INTERLOCK CIRCUIT FAILURE DETECTED - SERVICE REQUIRED

Cause	Remedy	Reference
Meaning: The chamber board detected a state where the chamber lid was open but the interlocks were not broken.		
Random noise event..	Open the chamber lid, if the circuits are functioning correctly the error will be cleared automatically. If unsuccessful, try turning the power off and on to reset the board.	

As the sample chamber lid is closed, the lid interlock switch closes before the “lid closed” sensing switch does. This creates a state where the lid is “open” but the interlock is closed.	Adjust the switches per procedure.	Procedure 7.5.
X-ray tube arcing. The noise generated during an arc can disrupt the chamber board.	Run at low tube voltage to verify. See *High voltage arcing*.	
Faulty chamber control board.	Verify by substitution, replace if required.	Procedure 9.3.1.
Faulty primary lid interlock switch.	Test with an ohmmeter, replace if required.	Adjust per Procedure 7.5.

ION PUMP CURRENT IS HIGH (ECD)

Cause	Remedy	Reference
High gas load on the ion pump due to temporary outgassing (usually after a detector warm-up).	Wait 4 hours to allow the ion pump to remove the gas. (It is normal for the current to be 2-3 times higher at room temperature than when the coolers are on.)	
Poor vacuum in the detector housing, or faulty ion pump.	Verify by determining the minimum detector temperature attainable. If the detector operates normally, moderately high ion pump current (less than 100 µA) is tolerable but will reduce the ion pump's life. If a detector temperature sufficient to operate (less than 190 K) is not possible, replace the ECD detector assembly.	Procedure 7.24 or ECD STATUS screen.
Faulty ECD control board generated a false error message.	Verify by measuring the ion pump current signal with a voltmeter at the ECD board J5 pins 5 to 6 (1mV=1µA). If less than 300 mV the I.P. CURRENT OK light should be on. If it is off, replace the ECD control board.	Procedure 9.3.7. 5919-0207 "ion current ok"
Faulty chamber control board performed an inaccurate voltage measurement.	Verify by measuring the ion pump current signal with a voltmeter at the ECD board U5-1 (TP1-9 x 10) and comparing with the ECHOA QV06 response. Replace chamber control board if required.	Procedure 9.3.1.

LOW ENERGY SENSITIVITY IS POOR

Cause	Remedy	Reference
Analysis conditions and/or method are not optimized for the elements of interest.	Contact a factory applications specialist.	
Fast discriminator requires adjustment.	Adjust the fast discriminator control for 150 ±25 counts/sec with the X-rays off.	Procedure 7.2.

Noise pickup caused high fast discriminator values forcing a f.d. readjustment based on this artificially high background noise level. The f.d. threshold is now so high it is cutting off the low energy portion of the spectrum.	Run a resolution test. The noise pickup will also cause poor resolution. If poor resolution is found, correct it first and the low energy sensitivity problem will most likely be corrected. See: *Resolution is poor.*	Procedure 7.11.
Low detector bias supply voltage.	Verify on the GENERAL STATUS screen. The bias supply 1v should be greater than 0.95. If it is low, replace the bias supply module.	Procedure 9.3.3.
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Contamination of the detector's beryllium window.	Clean the window per procedure. CAUTION - READ THE PROCEDURE, SERIOUS DAMAGE IS POSSIBLE.	Procedure 7.25.
Faulty detector assembly.	Verify by substitution, replace if required.	Procedure 9.6.

NO SPECTRUM IS PRODUCED

ACQUISITION FAILED TO INITIATE

Cause	Remedy	Reference
Excitation voltage set too low for the filter selected.	Raise the X-ray kV setting or choose a different filter.	
No sample in the analysis position selected.	Install a sample.	
X-ray tube anode current set to zero.	Select a new mA value.	
Fast discriminator requires adjustment.	Adjust the fast discriminator control for 150 ±25 counts/sec with the X-rays off.	Procedure 7.2.
ADC or chamber board requires a logic reset.	Exit the program, turn the power off for 5 seconds and then back on, restart the program.	
Output cable between the bias supply board and the pulse processor board is disconnected.	Connect the coax cable.	
A board is not inserted correctly in the card cage.	Turn off the power. Reseat the boards firmly.	
Detector high voltage bias is off.	Verify that the "HV" light on the bias supply is off, then see: *Detector high voltage bias is off.*	Figure 3.4.
Hardware failure which requires on-line diagnosis.	Set the program to SERVICE MODE via the TXCONFIG program and continue to the next cause.	Section 8.4, Service mode.
Check the system status screens for the following possible causes:		

Faulty power supply or adjustment required.	If a voltage is out of range, adjust per procedure (must use procedure values!) or replace the power supply.	Procedure 7.4.1.
Preamp reset rate is above 1 reset per 2 seconds (LN) or 10 resets per second (ECD), X-rays off.	See: *Preamp reset rate is too high.*	
Detector temperature is above 190 K (ECD).	See: *Detector temperature is too high.*	
Ion pump current is above 20 μA (ECD).	See: *Ion pump current is high.*	
No X-rays are being generated.	Turn on X-rays, if X-rays are being generated the preamp reset rate will increase substantially. See the following causes.	
No X-rays being generated (pa reset rate doesn't change) due to:		
Faulty voltage/current control board.	Verify with all entries except "HV monitor" in "X-rays on" portion of the GENERAL STATUS screen. Replace if required. If only "anode current" is bad it could be the tube, continue to next causes.	
Faulty X-ray high voltage power supply.	Verify with "HV monitor" entry on the GENERAL STATUS screen. Replace if required.	
Faulty X-ray tube.	If "anode current" is ≈ 0, measure resistance of tube filament. Good ≈ 0.1-2 Ω, bad = open. If the filament is good, tube may still be the problem. Replace if required.	5919-0161 J5 pins 2&3 (cable side only).
X-rays are being generated (pa reset rate changes) but no spectrum due to:		
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.1.
Faulty ADC interface board.	Verify by substitution, replace if required	Procedure 9.3.8.

PREAMP RESET RATE IS TOO HIGH (WITH X-RAYS OFF)

CHECK DETECTOR STATUS

Cause	Remedy	Reference
LN level is low.	Fill the dewar and wait 1-2 hours.	
The detector coolers have not been on long enough (ECD).	Allow 2 hours for the detector to reach operating temperature.	

The detector temperature is too high (ECD).	Verify on the ECD STATUS screen, detector should be less than 190 K. Or measure per procedure. If high, see: *Detector temperature is too high.*	Procedure 7.24.
Bias supply voltage is too high.	Verify on the GENERAL STATUS screen. Bias supply 1v should be less than 1.05. If high, replace the bias supply module.	Procedure 9.3.3.
Bias voltage selection jumper is not positioned correctly.	Check the yellow jumper wire inside the bias supply module. It should be inserted in the 600V socket (LN) or the 300 or 400V socket (ECD).	
Faulty detector assembly.	Verify by substitution, replace if required.	Procedure 9.6.

REPEATABILITY OF ANALYSIS RESULTS IS POOR

Cause	Remedy	Reference
Analysis conditions and/or method are not optimized for the elements of interest.	Contact a factory applications specialist.	
Fast discriminator requires adjustment.	Adjust the fast discriminator control for 150 ±25 counts/sec with the X-rays off.	Procedure 7.2.
X-ray stability is poor.	Verify by running the Stability test per procedure. If stability is poor, see: *X-ray stability is poor.*	Procedure 7.12.
Detector resolution is poor or is not stable.	Verify by running the Stability test per procedure. If the FWHM (also the peak count) stability is poor, or if the FWHM is high, see: *Resolution is poor.* Note, resolution can be affected by fan vibration which changes with temperature. If suspected, run resolution with fans at maximum by unplugging sensor lead on tube fan and heating enclosure fan sensor.	Procedure 7.12.
Sample positioning problem.	For systems with a sample tray, run the Tray Accuracy test or run with the single sample tray installed to verify.	Procedure 7.15.

RESOLUTION IS POOR (ZERO WIDTH IS HIGH))

CHECK DETECTOR STATUS

Cause	Remedy	Reference
Pulse processor count rate range selected is not suitable for the attempted analysis.	Select a lower range.	
Pulse processor gain switch is not set to “1.”	Set the switch to the “1” position.	
Fast discriminator requires adjustment.	Adjust the fast discriminator control for 150 ±25 counts/sec with the X-rays off.	Procedure 7.2.

System requires energy calibration.	Run energy calibration, zero width and resolution measurements are only valid when the system is in calibration.	Procedure 7.3.
Problem with the X-ray detector. Check system status (X-rays off) for the following:		
Preamp reset rate is above 1 reset per 2 seconds (LN) or 10 resets per second (ECD).	See: *Preamp reset rate is too high.*	
Detector temperature is above 190 (ECD).	See: *Detector temperature is too high.*	
Ion pump current is above 20 (ECD).	See: *Ion pump current is high.*	
Detector bias voltage is low.	Check the GENERAL STATUS screen "bias supply 1V." Should be greater than 0.95.	
Problem in the signal processing electronics due to:	Quick check: disconnect the small cable between the bias supply output and the pulse processor input. The zero width should be approximately 30 in medium range. If high, this is the problem. Not a comprehensive test, substitution is better.	
Faulty pulse processor module.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty detector bias supply module.	Verify by substitution, replace if required..	Procedure 9.3.3.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Detector body not isolated from ground.	Turn off the power. Disconnect the preamp cable from the bias supply board. For ECD: Disconnect the in-line connector J1 near the ion pump power supply, disconnect the ion pump cable from the ion pump, disconnect the ECD control board J4 connector. Measure the resistance between the detector body and a non-painted surface on the chamber wall. There should be no continuity (infinite resistance). If there is continuity, locate and eliminate the source.	See Installation portion of Procedure 9.6 for hints.
Electrical noise pickup caused by:	Best diagnostic method is process of elimination. Watch for drops in the zero width and/or fast discriminator values while eliminating possible sources. Run resolution test with source removed if possible. (Remember to reconnect it when done.)	Procedure 7.11.
Ion pump power supply (ECD).	Disconnect the in-line connector J1 near the ion pump power supply.	

X-ray voltage/current control board.	Disconnect J2 from the board.	5919-0161.
Noise on AC power line.	Use a power analyzer, install a power conditioner, or run the system from an alternate source to verify.	
Faulty ADC interface cable.	Verify by substitution, replace if required.	
Noisy DC power supply.	Verify by substitution of the power supply is best. Unplug the PS2 AC plug and watch for zero width drop (will turn off coolers on ECD systems so go fast).	
Microphonic (vibration induced) noise pickup caused by:	Best diagnostic method is process of elimination. Watch for drops in the zero width and/or fast discriminator values while eliminating possible sources. Run resolution test with source removed if possible.	Procedure 8.2.6.
An external vibration source.	The system should be on a stable floor. No rigid connections between the enclosure and a vibration source are allowed.	
Loud external noise source.	The detector is sensitive to acoustic vibration. Eliminate the source of the noise or provide sound and vibration isolation for the instrument.	
Cooling fan vibration.	Verify by disconnecting power to the fan. The X-ray tube fan has a connector. The enclosure fan has wires in motherboard J7.	
Faulty detector preamp board.	Verify by substitution, replace if required.	Contact factory.
Faulty detector assembly.	Verify by substitution, replace if required.	Procedure 9.6.

SAMPLE TRAY FAILED TO LOCATE HOME

CONFIGURATON ERROR - OPTIONS DON'T MATCH TXCONFIG SETTING

Cause	Remedy	Reference
Mechanical jam.	Check that the sample tray can be rotated one full rotation by hand with the power off.	
Motor or sensor connector is unplugged, or a wire is broken.	Check connections at the chamber distribution board. Motor is J3, sensor is J4.	Figure 3-4.
If the tray turns when the power is turned on, see the following causes:		
"Sample home" signal is not being generated correctly due to:	Verify with SAMPLE HOME LED on the chamber control board. With the power on, let the tray rotate. As the flag pin passes through the sensor (tray in position 1), the LED should turn on (always off otherwise). If bad see the following causes.	5919-0217 "SHD".

Flag is not breaking the light beam.	Verify by inserting opaque paper in sensor (located under the tray driver toward the rear). If the SAMPLE HOME LED turns on only when paper is inserted, the flag pin is missing or is too short. Try pushing down on the tray driver.	
Faulty optical home sensor.	To verify: Plug the tray sensor connector J4 into the chamber distribution board J5 (filter sensor position) and rotate the tray. If the FILTER HOME LED lights only when the flag is in the sensor, then the tray sensor is good, go on to next cause; otherwise replace the sensor.	Figure 3-4.
If the motor does not turn when the power is first turned on, see the following causes:		
Bad or missing “tray drive installed” jumper in the motor connector. If TXCONFIG is not set to number of postions=1, this will generate the configuration error message when QUANX is run.	The chamber board will not try to turn the tray unless a jumper is in J3 pins 5 to 6.	5919-0127 “tray in.”
Faulty chamber control board or stepper motor.	Verify by substitution.	Procedure 9.3.1 and 9.5.2.

SPECTRUM CONTAINS PERIODIC ERRORS

Cause	Remedy	Reference
Address conflict between the ADC interface board and some other device in the personal computer.	Change the address used for the ADC interface board per procedure.	Procedure 5.5.3.
Faulty ADC interface board.	Verify by substitution, replace if required.	Procedure 9.3.8.
Faulty ADC interface cable.	Verify by substitution, replace if required.	

STRAY LINES (UNWANTED ELEMENTS) APPEAR IN THE SPECTRUM

Cause	Remedy	Reference
Sample contamination.	Test with a known clean sample.	
Detector collimator is not installed or is incorrectly installed.	The collimator should be oriented so that the snout flat area is horizontal.	
A small amount of background contamination is normal.	Verify if the contamination is beyond specifications by running the test procedure.	Procedure 7.18.
Filter wheel positioning error.	Select the “no filter” position and verify visually that the filter wheel opening is approximately centered over the X-ray tube collimator hole. Centering is adjusted by moving the home sensor.	

Sample tray positioning error	Perform a test with the single sample tray installed.	
X-ray tube sourced contamination.	Run a test with the thin copper filter. This filter will block any stray lines from the tube.	
Contamination of the detector's beryllium window.	Clean the window per procedure. CAUTION - READ THE PROCEDURE, SERIOUS DAMAGE IS POSSIBLE.	Procedure 7.25.
Faulty detector assembly.	Verify by substitution, replace if required.	Procedure 9.6.

X-RAY STABILITY IS POOR

Cause	Remedy	Reference
After running the Stability test, the total and peak RSD values are **both** poor due to an unstable tube output caused by one of the following:		Procedure 7.12.
Faulty X-ray high voltage power supply.	Verification by substitution is best. Alternative is to set the program to monitor the "high voltage control" and "H.V. monitor" on the GENERAL STATUS screen. Print or save to a file over a many hour period. If the analysis instability coincides with instability in the "monitor" but not the "control" signal, the supply is the most likely cause.	Procedure 9.4.1.
Faulty X-ray control board.	Same remedy as above except set the program to monitor only the "high voltage control" and "anode current".	Procedure 9.3.6.
Faulty X-ray tube.	Verify by substitution, replace if required.	Procedure 9.7.1.
After running the Resolution test, the total RSD is good but the peak RSD is poor due peak shift or unstable resolution caused by one of the following:		Procedure 7.12.
Faulty pulse processor board.	Verify by substitution, replace if required.	Procedure 9.3.2.
Faulty ADC board.	Verify by substitution, replace if required.	Procedure 9.3.4.
Faulty power supply.	Measure and adjust per procedure. Replace if required.	Procedure 7.4.1.
Unstable resolution.	See: *Resolution is poor*.	

X-RAYS DO NOT TURN OFF

X-RAYS NOT OFF - HARDWARE PROBLEM. 'CONFIRM' SIGNAL FAILURE.

Cause	Remedy	Reference
Faulty chamber control board.	Replace chamber control board.	5919-0217 "confirm" Procedure 9.3.1.

X-RAYS TURN OFF DURING AN ACQUISITION

X-RAYS NOT ON - HARDWARE PROBLEM. 'CONFIRM' SIGNAL FAILURE
X-RAYS NOT ON - HARDWARE PROBLEM. 'INTERLOCK HAS OPENED'
X-RAYS NOT ON - HARDWARE PROBLEM. 'WARNING LIGHT IS NOT ON'

Cause	Remedy	Reference
Interlock opened.	See the appropriate section of: *X-rays will not turn on.*	
High voltage arcing.	See: *High voltage arcing.*	

X-RAYS WILL NOT TURN ON

X-RAYS NOT ON - HARDWARE PROBLEM. 'CONFIRM' SIGNAL FAILURE
X-RAYS NOT ON - HARDWARE PROBLEM. 'INTERLOCK HAS OPENED'
X-RAYS NOT ON - HARDWARE PROBLEM. 'LID IS OPEN'
X-RAYS NOT ON - HARDWARE PROBLEM. 'WARNING LIGHT CURRENT IS HIGH
X-RAYS NOT ON - HARDWARE PROBLEM. 'WARNING LIGHT IS OFF

Cause	Remedy	Reference
Symptom: The X-ray warning light is off (it did not even flash on) and the computer says it is off.		
The warning light connector is unplugged.	Plug in the rear panel connector.	
Faulty display board.	Verify by checking the chamber board lights. If the ENABLE LIGHT LED is on but the warning light is off, replace the display board. Otherwise see next cause.	Procedure 9.3.5.
Faulty chamber control board.	Verify by checking its lights. When the X-rays attempt to turn on the ENABLE LIGHT LED should light, if not replace the chamber board.	5919-0217 "enable lamp" Procedure 9.3.1.
Symptom: The X-ray warning light flashed on then off when the X-rays were turned on. The light stays off and the computer says it is off, and the ENABLE LIGHT LED on the chamber board is off. *Note: QUANX program version 1.35c has a bug which will cause a similar symptom. If the confirm signal is bad, the light will flash, an error message will flash on the screen and the program will return to the menu. In this case, see the confirm signal symptom below.*	Explanation: High current surge on the 24V supply when the X-rays tried to turn on. The 24V drops low and the chamber board registers this as an open interlock and turns off the warning light. The 24V recovers so the PC doesn't detect an "interlock" failure but does detect the fact that the light is off. The ENABLE light turned off from the voltage drop, not by computer command. The computer doesn't send an X-ray off command until the error message is cleared from the screen by the operator.	

Shorted X-ray tube.	Use TXCONFIG to set SERVICE MODE to YES. Disconnect the HV cable from the X-ray high voltage power supply (not from the tube!). To prevent excessive tube filament heating, also disconnect the X-ray control board J5 and jumper pins 4&5 on the board. Turn on X-rays (10kV or less), if the X-ray warning light comes on as normal, the tube is the most likely problem (if not, see next cause). It's possible the HV supply is the problem but only under load. Replace one of the two to verify.	Procedure 9.7.1.
Faulty X-ray high voltage power supply.	Use TXCONFIG to set SERVICE MODE to YES. Unplug J4 from the X-ray control board to eliminate the HV supply. To prevent excessive tube filament heating, also disconnect J5 and jumper pins 4&5 on the board. If the X-ray warning light comes on as normal now, replace the HV supply.	Procedure 9.4.1.
Faulty X-ray control board.	Use TXCONFIG to set SERVICE MODE to YES. Unplug J2 and J3 from the board. Use a paper clip to short the cable ends together, J2 pin 1 (orange) and J3 pin 2 (blue). If the X-ray warning light comes on as normal now, replace the board. Note, most likely failure is shorted capacitor C13.	Procedure 9.3.6.
Symptom: The X-ray warning light is on but the computer says it is off.	Explanation: This means the current flowing through the chamber control board resistor R112 is low, which the computer evaluates as "off."	
One of the 8 LED segments in the light is open (causing 4 to go out).	Verify visually, every other segment will be out making a diffused light-dark pattern. Also the chamber control board LIGHT ON LED is off. If so, replace the display board.	Procedure 9.3.5.
The display board is shorting against the chamber lead shield.	Verify by removing lid cover screws and starting the X-rays with the board well clear of the lead.	Procedure 9.3.5.
The display board requires adjustment.	Best to replace the board. If not available, adjust the display board pot to achieve 2.10V at the chamber control board resistor R112. Allow the light to run 10 minutes before making the adjustment.	None given.
Faulty chamber control board.	Verify and replace the board. The "off" signal trips at R112 voltage of 1.8V.	Procedure 9.3.1.
Symptom: The computer says an interlock is open.	Explanation: Chamber board J1-7 INTERIN signal is not at +24V.	Drawing 0110-0632 for interlock overview.
Power supply is faulty or requires adjustment.	Measure the +24V PS2-A output per procedure.	Procedure 7.4.1.

Open interlock switch or connection.	Bypass the top cover and enclosure cover interlock switches by pulling out on their actuator rods. If all internal interlocks are closed, both the INTERLOCK LED on the X-ray control board and the INTERLOCK IN LED on the chamber control board should be on. If they are on, see the next cause. If not, check the tube, detector, and chamber lid switches and the tube filament cable jumper J5-4&5.	0110-0632
Faulty chamber control board generated a false signal.	Verify and replace the board.	5919-0217 "interlock".
Symptom: The computer gives a "confirm signal" error message.	Explanation: The X-rays are not really on, no power is leaving the chamber control board to power the X-ray HV supply. The INTEROUT voltage is low, it should be approximately 24V.	5919-0217 "confirm".
Faulty chamber control board.	Verify and replace the board.	Procedure 9.3.1.
Symptom: The computer gives a “light current is high” message.	Explanation: The current through the chamber board resistor R112 is high.	
Shorted LED segment on the display board.	Verify by removing the board and turning on the X-rays. 3 or 4 of the 8 segments will be on unusually bright. The remaining segments will be on dim. If so, replace the board.	Procedure 9.3.5.
Faulty chamber control board.	Verify and replace the board. High current signal trips at R112 voltage of 2.5V.	Procedure 9.3.1.
The display board requires adjustment.	Best to replace the board. If not available, adjust the display board pot to achieve 2.10V at the chamber control board resistor R112. Allow the light to run 10 minutes before making the adjustment.	None given.

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11. Optional Equipment

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11.1 Introduction

This section provides an overview of the some of the standard options available on the QuanX. Each subsection includes a functional description and an installation guide if applicable.

11.2 Helium Flush

11.2.1 Description

The helium flush option is required for light-element analysis of liquid samples. Because low energy X-rays are absorbed by the air in the chamber, the air must be removed to perform the analysis. With non-liquid samples the chamber is evacuated with a vacuum pump. Since liquid samples will vaporize in a vacuum, the air is displaced using helium gas.

See Figure 11-1 for an illustration of the manifold. The hardware consists of a manifold with a pressure regulator, pressure switch, and two solenoid valves mounted to it. A hose is attached between the manifold and the sample chamber wall to carry the helium. The two valves are used to provide dual flow rates. When an acquisition is started, a large volume of air must be displaced from the sample chamber. A two minute high flow, or *purge*, cycle is initiated by the analysis program. After the two minute period, the high flow valve turns off and the low flow valve turns on. Only a small flow is required during the analysis to maintain the chamber environment.

The pressure regulator is used to provide a known, stable pressure inside the instrument regardless of the helium inlet pressure (within the specified limits). The flow rates are then set by the manifold orifices. The pressure switch is used to detect a low flow condition which would adversely affect the analysis performance. If the helium tank runs out, the analysis program will not allow an analysis to begin, or will stop an analysis already in progress and display a warning message.

11.2.2 Specifications

Inlet fitting: ¼ inch hose barb

Inlet pressure: 15 to 65 psig (103-448 kPa)

Consumption (flow rate): high flow cycle - 15 scfh (425 l/h)
low flow cycle - 5 scfh (142 l/h)

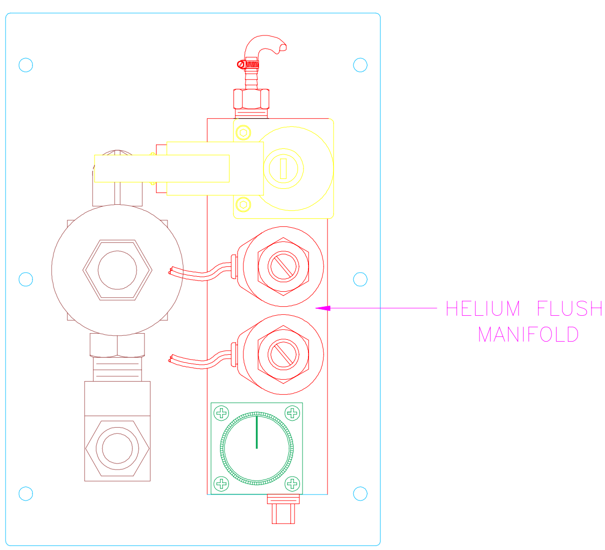

Figure 11-1 Helium flush manifold, vacuum/helium panel inside view

11.2.3 Installation

Disregard this section if the option was installed at the factory.

1. Remove the detector assembly as detailed in Procedure 9.6. This is required to gain access to the chamber wall fitting.
1. Remove the brass hole plug from the chamber wall. It is located next to the detector port opening.
1. Install the hose barb nipple in the chamber wall. Use sealant on the threads.
1. Remove the vacuum/helium panel from the rear panel of the instrument. This is the middle panel with the vacuum nipple. Allow the panel to hang from the large vacuum hose.
1. Remove hole plugs and dummy screws as required from the panel and install the helium manifold.
1. Remove the motherboard access panel from the rear panel.
1. Connect the helium manifold cable to the motherboard J6 connector. This is the white 6-pin connector located behind the large black J7 connector (see drawing 5911-0219 for the location). Align the connector locking ramps for proper orientation. Also check that it is not one pin off (front to rear) as the connector has no protection against this.
1. Connect the small hose from the helium manifold to the hose barb fitting on the sample chamber.
1. Reinstall the vacuum/helium panel. Make sure the helium hose is not kinked.
1. Reinstall the detector assembly per procedure.
1. Test the operation per Procedure 7.23.

11.3 R-Theta Sample Stage

11.3.1 Description

The R-Theta stage is used to hold fixed disk media. The disk platters are held from the center rather than the edges as in a normal sample tray. Sample positioning is fully automated and is under the control of the analysis program, RTQUANX. Positioning is accomplished by linear front-to-rear translation and up to 360° rotation. See the QuanX Operators manual supplement for more information on the program operation.

The stage uses two stepping motors, one for translation and one for rotation. The translation axis uses the drive circuitry normally used for the sample tray rotation. The rotation axis uses circuitry included only for optional equipment. Each axis has an optical sensor and flag which are used to establish a “home” reference position. The translation axis also includes emergency stop switches which interrupt the motor power if the stage travels beyond its normal operating range.

A special chamber board ROM chip (P/N 8140-0129) is required to operate the R-Theta stage. Also, the chamber board switches SW1 and SW2 must be set to the THETA position.

For constant rotation option, remove jumper between pins 7 and 8 of J7 on R-Theta stage cable. Retain jumper by taping to cable.

See Figure 11-2 for an illustration of the R-Theta stage. Technical drawings are included in Section 12, Drawings and Schematic Diagrams.

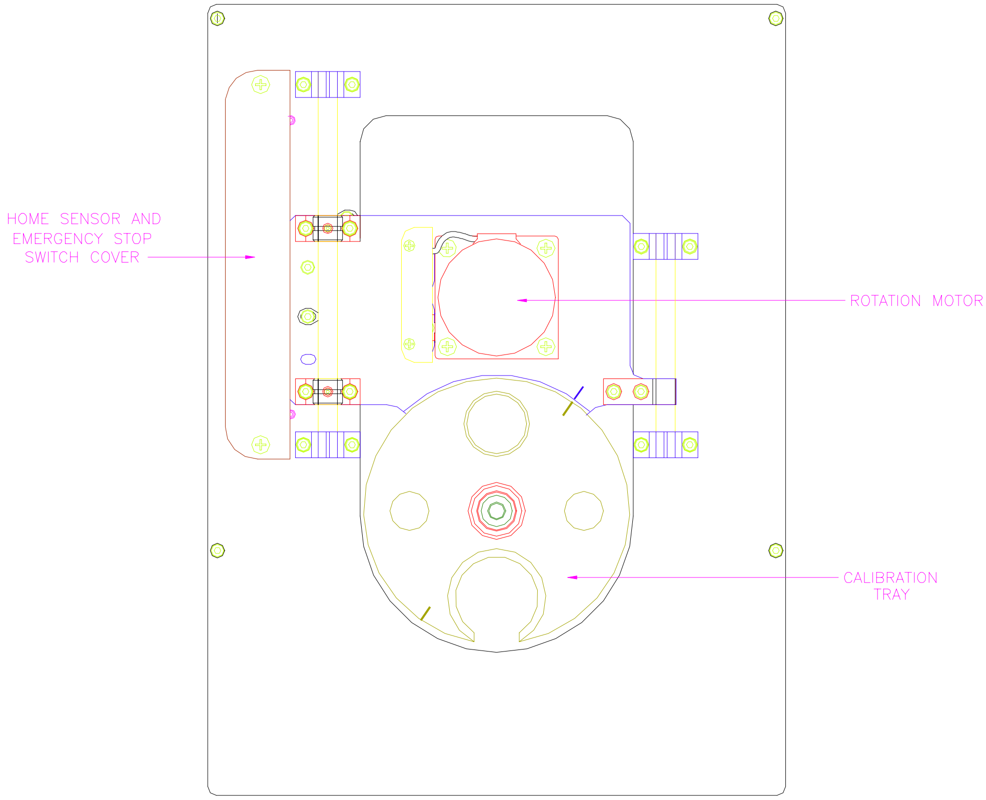

Figure 11-2 R-Theta stage, top view

11.4 Y-Theta Sample Stage

11.4.1 Description

The Y-Theta stage is used to hold silicon wafers. Sizes accommodated are 4, 5, 6 and 8 inch wafers. Sample positioning is fully automated and is under the control of the analysis program, YTQUANX. Positioning is accomplished by linear front-to-rear translation and up to 360° rotation. See the QuanX Operators manual supplement for more information on the program operation.

The stage uses two stepping motors, one for translation and one for rotation. The translation axis uses the drive circuitry normally used for the sample tray rotation. The rotation axis uses circuitry included only for optional equipment. Each axis has an optical sensor and flag which are used to establish a “home” reference position. The translation axis also includes emergency stop switches which interrupt the motor power if the stage travels beyond its normal operating range.

A special chamber board ROM chip (P/N 8140-0130) is required to operate the Y-Theta stage. Also, the chamber board switches SW1 and SW2 must be set to the THETA position.

See Figure 11-3 for an illustration of the Y-Theta stage. Technical drawings are included in Section 12, Drawings and Schematic Diagrams.

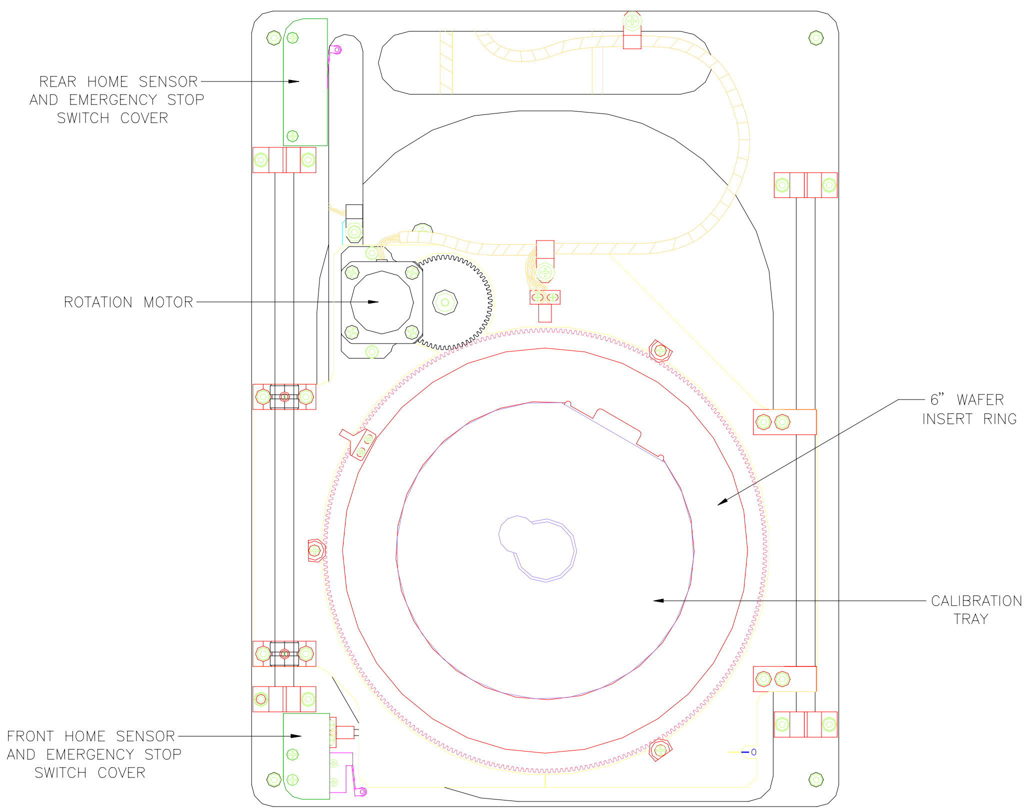

Figure 11-3 Y-Theta stage, top view

11.5 XY Sample Stage

11.5.1 Description

The XY stage is used to analyze dried water samples. Sizes accommodated are either 2mXa sample frames, two 5cm square samples or two 32mm round disks. Sample positioning is fully automated and is under the control of the analysis program, XYQUANX. Positioning is accomplished by linear front-to-rear and left to right translations. See the QuanX Operators manual supplement for more information on the program operation.

The stage uses two stepping motors for translation. The X translation axis uses the drive circuitry normally used for sample tray rotation. The Y translation axis uses circuitry included only for optional equipment. Each axis has an optical sensor and flag which are used to establish a “home” reference position. Both axes also includes emergency stop switches which interrupt the motor power if the stage travels beyond its normal operating range.

A special chamber board ROM chip (P/N 8140-0131) is required to operate the XY stage. Also, the chamber board switches SW1 and SW2 must be set to the THETA position.

See Figure 11-4 for an illustration of the XY stage. Technical drawings are included in Section 12, Drawings and Schematic Diagrams.

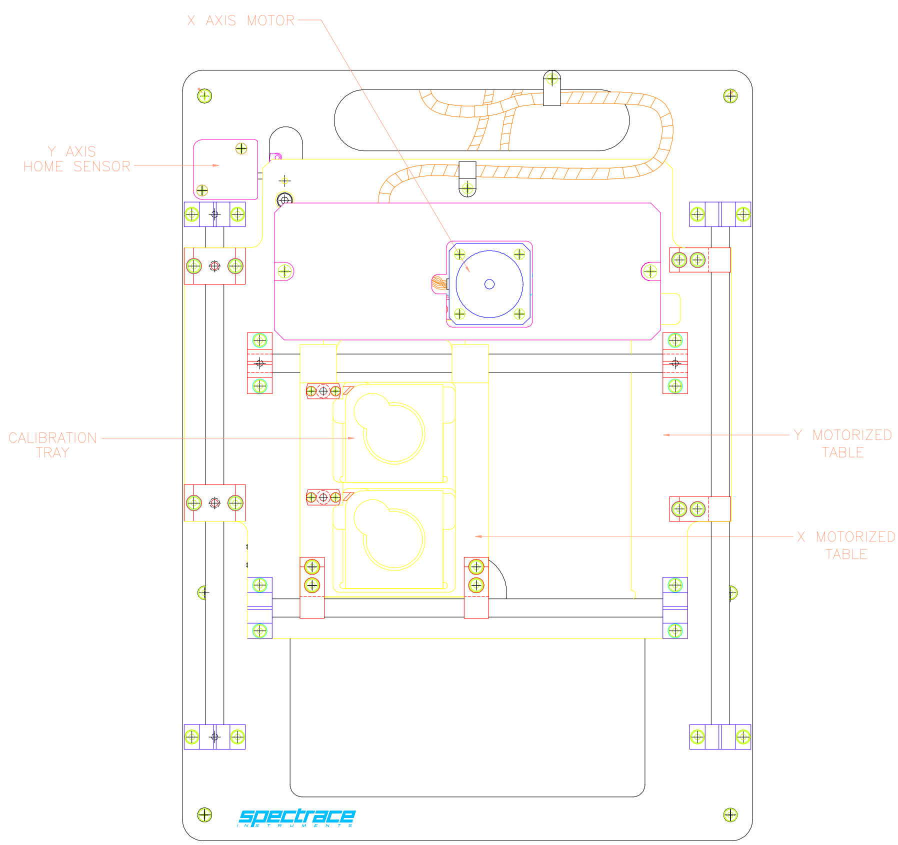

Figure 11-4 XY stage, top view

11.5.2 Installation

Disregard this section if the option was installed at the factory. The below section 11.5.2.1 is to retro fit system that has ECD or 30mm LN detectors, otherwise skip to section 11.5.2.4.

11.5.2.1 Installing the Detector Adapter Ring

In order to accommodate an X-Y stage, the ECD and 30mm LN model detectors must be moved about 0.15” down to clear the stage. Installing the adapter ring between ECD flange and baseplate will do this.

1. Turn off the instrument power switch. For ECD systems, disconnect the instrument power cord. This is required to remove all power from the chamber board socket.
2. Remove the baseplate cover and tray support pads, if present, from the baseplate.
1. Remove the tray drive assembly, if present.
1. Detector removal: follow the instructions in the Technical Manual section 9.6.1 or 9.6.2 as appropriate.
1. Apply a thin coat of vacuum grease on the new o-ring (provided) and install it into the adapter o-ring groove.
1. Transfer the insulator from detector mounting flange to the top of the adapter ring, and place them both on top of the detector mounting flange (see the attached drawing SKT-8000-1).
1. Align the holes in the adapter and insulator with the detector flange screw holes. Temporarily install two set screws #8-32 x ¾” (provided) into two opposite detector flange screw holes, to hold the parts in place and align the adapter ring with the detector.
1. Install the detector-adapter assembly temporarily, onto the chamber baseplate, holding the detector-adapter assembly with two mounting screws.
1. Remove the set screws, and verify that the adapter flange depresses the interlock switch lever located on the chamber port.
1. Install the two remaining mounting screws which hold the detector to the chamber baseplate. Tighten all four screws evenly.
1. Follow the Technical Manual instructions (section 9.6.1 or 9.6.2) to complete the detector installation.
1. Replace the old detector collimator with the new one (provided).

11.5.2.2 Attaching the Stage

1. If a detector adapter ring has just been installed, go to step 5.
1. Turn off the instrument power switch. For ECD systems, disconnect the instrument power cord. This is required to remove all power from the chamber board socket.
1. Remove the baseplate cover and tray support pads, if present, from the baseplate.
1. Remove the tray drive assembly, if present.
1. Replace the old filter wheel collimator with the new one (provided).

1. You should now see the distribution board with connectors for the X-Y stage cables. Note the markings on the connectors on both the cables and the distribution board.
1. Rest the left side of the stage on the left side of the baseplate, holding up the right side of the stage to allow access to the distribution board connectors.
1. Connect all four connectors to the chamber distribution board by matching the numbers marked on the connectors. Dress the cables inside the chamber for no interference with the stage.
1. Slowly lower the right side of the stage until it is resting flat on the baseplate, being careful not to pinch any cables.
1. Verify there is no interference with cables by moving the stage over its full Y-axis stroke (forward/backward).
1. Install the two #6-32 x 1/2” flat head screws (item #7) first, on the left side of the stage. This aligns the stage with the baseplate center line. Verify again that the stage is resting flat on the baseplate and that there is no interference. Install the two remaining screws (#6-32 x ¼” socket head) on the right side.
1. Manually slide the stage forward and backward, and left and right. It should slide smoothly, without binding.

Do not power up the instrument until the chamber control board ROM has been changed.

11.5.2.3 Changing the Chamber Control Board ROM

Reference section 9.3 in the Technical Manual.

1. See Figure 3-4 in the Technical Manual for the location of this board.
1. Turn off the instrument power switch. For ECD systems, disconnect the instrument power cord. This is required to remove all power from the chamber board socket.
1. Remove the board by pulling out on the two ejection ears located on the top of the board. Lift the board out of the card cage.
1. If a replacement board with the X-Y Stage ROM already installed is available, go to step 8. Otherwise, continue.
1. Use a static guard or other means to remove any static electricity before touching the ROM IC.
1. Note the QuanX ROM location and orientation; it is p/n 8140-0127B. Carefully remove the ROM, using a small flat blade screwdriver to alternately pry each end up a small amount at a time.
1. Install the X-Y Stage ROM, p/n 8140-0131, being careful not to bend any leads.
1. Verify that switches SW1 and SW2 are both set to the THETA position.
1. Install the board with the X-Y stage ROM, pressing firmly until it snaps into place.
1. Connect the power cord and turn on the power switch. The stage should position itself at the home positions for X (left most position) and for Y (most rearward position).

11.5.2.4 Stage Height Adjustment

Scope and purpose

Note that this adjustment is only required if the X-Y stage has not been setup at the factory for the specific instrument it is to be used with.

Set the height of the X-Y Stage to compensate for variations in the x-ray spot location and alignment. Proper height adjustment maximizes the detected flux and minimizes the sensitivity to stage height variations.

Test equipment

Thin (about 0.015") #6 flat washers
Brass or copper sample
Single sample frame support

Test conditions

The X-Y stage with collimators and the X-Y stage ROM have been installed.

Optional - The diagnostic diskette has been installed and the XYQUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

1. Start with the stage installed at the minimum height (no washers).

1. Place the brass or copper sample in tray position 1E, using the single sample frame support.

1. Select the TRAY ACCURACY test from the procedure menu and press SETUP, or set up the following conditions:

Overall setup (using MEDIUM count rate range):

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	20 kV	Method	:	Linear
Tube current	:	0.20 mA (0.40 ECD)	Mode	:	Run unknowns
Filter used	:	Pd thin	Std. File	:	300
Livetime	:	100 sec			
Preset count	:	0 k			
Max energy	:	20 keV			
Atmosphere	:	Air			
Warmup	:	5 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref file no.	:	300	Spectrum	:	Yes
Elements of int	:	Brass	Intensities	:	Yes
			File number	:	300
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING
1. BRASS - GROSS ROI <7200 - 10080 EV>

4. Highlight ACQUISITION PARAMETERS and press RUN. Answer 1 for the number of unknowns to run.
1. The dead time should be approximately 50%. If not, press ACQU MENU & ACQU PAR and adjust the tube current.
1. After the acquisition is complete, highlight SPECTRUM PROCESSING and press RUN. Answer 1 for the number of samples to run.
1. Display the spectrum by pressing DISP SPEC then typing C to select the current spectrum. Write down the value of the ROI gross counts displayed on the upper right corner of the screen.
1. Add one washer under each corner of the stage and repeat the previous steps (do not change the tube current).
1. Continue adding washers one at a time and noting the gross counts. The count value should start low, achieve a maximum, and start dropping as more washers are added. The correct stage height is the one with the highest gross counts.
1. Install the corresponding number of washers under the stage. If the X-Y stage is to be removed and reinstalled in the future, it is a good idea to glue the washers to the bottom of the stage to avoid losing them.

11.5.3 Stage Position Calibration

Scope and purpose

The purpose of this procedure is to determine positional offset corrections which can be used to eliminate any errors between the actual and theoretical location of the home position (x=0, y=0).

Note that this calibration is required only if the X-Y stage has not been setup at the factory for the specific instrument it is to be used with.

The positional accuracy of the stage is dependent on the accuracy of the home sensor locations. Manually positioning the home sensors to within a few thousandths of an inch is difficult, so a means of correcting for the actual home locations is used instead. A calibration pin is built into the stage at the design location x = 0.230” (78 steps), y = 0.590” (118 steps). The actual location of the calibration pin is measured by using the Table mode to scan the pin. A default XYTABLE file for this purpose is provided with the software, or one can be created with a text editor. Any difference between the measured location of the pin and its design location is an offset error.

The XYQUANX program will automatically correct for these offsets but their values must be manually entered. The X and Y offsets are entered from the Test Procedures menu. The maximum allowed correction is +/-20 steps for X and +/-12 steps for Y (about +/-0.06”), but typically the corrections will be only a few steps.

Test equipment

31 mm copper sample

Test conditions

The **X-Y stage**, the **X-Y filter wheel collimator**, **X-Y detector collimator**, **X-Y detector adapter ring** (if required) and **X-Y chamber control ROM** have been installed.

Optional - The diagnostic diskette has been installed and the XYQUANX program has the active directory set as C:\SPECTRAC\QTESTLN or C:\SPECTRAC\QTESTECD for an LN or ECD system, respectively.

Procedure

1. Verify that a file named XYTABLE.CP is present in the same directory as XYQUANX.EXE. This is a text file with approximately 30 positions centered around x = 078 steps, y = 118 steps. If there is another file named XYTABLE, rename it. Now rename XYTABLE.CP to XYTABLE. There should be no file name extension.

1. Start XYQUANX. Verify energy calibration by running Energy Calibration using the copper sample.

1. Select the Manual Position Calibration test from the procedure menu and press SETUP, or set up the following conditions in the Setup menu: (*P = procedure number from the Procedure menu)

Overall setup (using the HIGH count rate range):

ACQUISITION PARAMETERS			ANALYSIS TECHNIQUE		
Tube voltage	:	25 kV	Method	:	No Analysis
Tube current	:	0.50 mA (ECD)	Mode	:	Run unknowns
Filter used	:	Cellulose	Std. File	:	*P00
Livetime	:	25 sec			
Preset count	:	0 k			
Max. energy	:	20 keV			
Atmosphere	:	Air			
Warm-up	:	5 sec			
SPECTRUM PROCESSING			SAVE ON DISK		
Ref. file no.	:	*P00	Spectrum	:	Yes
Elements of int.	:	CU	Intensities	:	Yes
			File number	:	*P00
			Results	:	No
			Ext. program	:	None

Spectrum processing setup

SPECTRUM PROCESSING	
1.	CU - GROSS ROI <7900 - 8160 EV>

3. Set the initial positional offset corrections to zero. The offset corrections can be read and changed from the Test Procedure menu. This menu is reached from the Setup menu by pressing F4 then F5. Push F3 for the x position correction and F4 for y position correction.

3. Go to the Setup menu and select XY STAGE (F7). Select TABLE mode and return to the top level (Procedure) menu.
4. Press RUN and then ENTER when the first sample name appears.
1. The dead time should be between 30% and 40% at some point during the run. If not, repeat the run with the tube current adjusted accordingly.
1. The peak copper counts should be printed after each data point. I f not, push F6 when in Main menu, set print results after each sample to YES. The count values should increase to a maximum, then decrease for the Y portion of the scan, and then do the same for the X portion. The maximum count values should be at least 100,000. If not, increase the acquisition time.
1. Note the X and Y positions with the maximum peak counts. Calculate the correction factors using the following formulas: X Position Correction = Xmax - 78 and the Y Position Correction = Ymax - 118. These corrections must be entered into the program from the Test Procedures menu under X POS. CORR (F3) and Y POS. CORR (F4) respectively.
1. After entering the corrections, run the test again to verify that the maximum counts occur at x = 78+/-2 and y = 118+/-1. If not, rerun the test with a longer preset livetime after resetting the corrections to zero. If the maximum counts (with corrections) still do not occur at x = 78+/-2 and y= 118+/-1, further diagnostic tests are needed, starting with a check of the stage installation and a stability test. Refer to the Technical Manual sections 7 and 10 for the stability test and other diagnostics.
1. Rename XYTABLE back to XYTABLE.CP so that new XYTABLE files can be created without erasing XYTABLE.CP.

DISCARD THIS PAGE

12. Drawings and Schematic Diagrams

Two types of drawings are included in this section: Assembly Drawings and Schematic Diagrams. Some assemblies have both types of drawings, for example PC boards. The Table of Contents includes both drawing numbers for each item, if they exist. However, the actual drawings are sorted numerically for easy access. The Table of Contents is divided into System and Options sections. The System section contains drawings common to all models.

Table of Contents

System

Schematic	Assembly	Title
0150-0112		QuanX Block Diagram
0110-0632		Safety Interlock Circuit
	9100-4901	QuanX Generic
	8100-7401	Filter Wheel Assembly
	8100-7403	Power Supplies Assembly
	8100-7404	50kV-2mA Power Supply Assembly
	8100-7405	Card Cage Assembly
	8100-7406	Latch Assembly
0110-0633	8100-7407	AC Distribution Box
	8100-7408	Vac/He Flow Panel Assembly
	8100-7411	Base Plate Assembly
	8100-7412	Chamber Lid Assembly
	8100-7413	PS3 ±12V Linear Power Supply
	8100-7414	PS4 ±24V Linear Power Supply
	8100-7432	PS2 A&B 24V Switching Power Supply
	8100-7437	Single Sample Tray Assembly
5919-0161	5911-0220	Voltage/Current Control Board
5919-0181	5911-0181	ADC Interface Board - old
5919-0224	5911-0224	ADC Interface Board - new
5919-0225		ADC Micro Board
5919-0216	5911-0216	Distribution Board
5919-0217	5911-0217	Chamber Control Board
5919-0218	5911-0218	Display Board
5919-0219	5911-0219	Mother Board
5919-0222	5911-0222	Pulse Processor Board

System

Schematic	Assembly	Title
	5101-0201	Filament Cable
	5101-0225-02	Vacuum Sensor Cable
	5101-0232-02	X-ray Power Supply Control Cable
	5101-0233	ADC Interface (Data Acquisition) Cable- old
	5101-0382	ADC Interface Cable - new
	5101-0366	Chamber Feedthru Cable
	5101-0367	Chamber Lid Cable
	5101-0368	Warning Light Cable
	5101-0371	AC Distribution Power Tray Cable
	5101-0372	DC Power Cable
	5101-0373	Voltage/Current Board Power Cable
	5101-0374	24V-PS2 AC Power Cable
	5101-0375	Cable Harness
	5101-0378	X-ray Supply Power Cable

Options

Schematic	Assembly	Title
	8100-7402	Spinner Drive Assembly
	8100-7409	Helium Flush
	8100-7410	Tray Drive Assembly
	8100-7415	Cooler Power Supply
	8100-7416	20 Position Sample Tray Assembly
	8100-7426	ECD Support Tray
	8100-7428	LN Sensor
	8100-6207	Ion Pump Assembly
0110-0634	5911-0223	Pre-amp Board-ECD/4 Terminal FET
0110-0609	5911-0128	Pre-amp Board-ECD/3 Terminal FET
50500-02	5911-0128	Pre-amp Board-LN/3 Terminal FET
5919-0194		Bias Supply Board-ECD Version
5919-0196		Bias Supply Board-LN Version
5919-0207	5911-0221	ECD Control Board-QuanX
	5101-0237	Fan Cable
	5101-0317-01	Ion Pump High Voltage Cable
	5101-0322-02	ECD Control Cable
	5101-0369	ECD Power Cable
	5101-0370	AC Power Cable
	5101-0376	Ion Pump Power Cable
	8100-7450	R-Theta 2 Table
	8100-7451	R-Theta 2 Slide
	8100-7452	R-Theta 2 Disk Holder and Weight Set

Options

Schematic	Assembly	Title
	9100-4918	R-Theta 2 Stage
	8100-7454	Y-Theta Motorized Table
	8100-7455	Y-Theta Slide
	9100-4915	Y-Theta Stage
	9100-4922	X-Y Stage